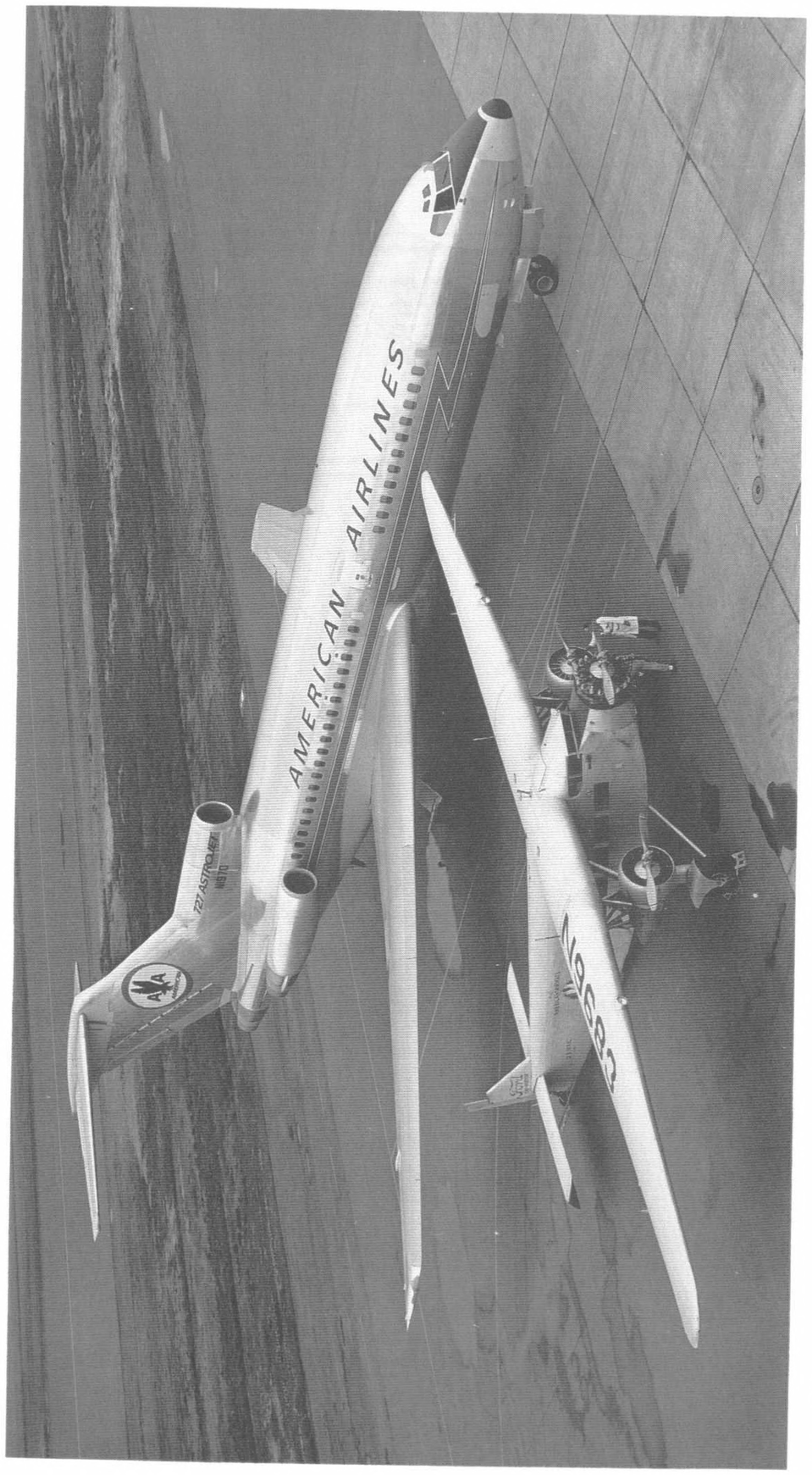


Airliners 36 years apart. American Airlines flew its refurbished 14-passenger Ford 5-AT Trimotor, a 'giant airliner' of 1928, to Renton for the rollout of its first 94–119 passenger trimotor Boeing 727–23, itself a small airliner by 1964 standards. (*Boeing Photo P–33014*)

Boeing Aircraft

since 1916

Peter M Bowers

Naval
Institute
Press

DESIGNATIONS AND MARKINGS

A better appreciation of the Boeing aeroplanes, their usage, and actual period of service can be had from an understanding of the company model designation system, the designation systems of the two principal US military services, and the constantly changing military markings. These are all described in this chapter rather than being presented throughout the book as they occur.

MANUFACTURER'S MODEL DESIGNATIONS

In 1916, very few aircraft manufacturers had systematic designation systems, and Boeing was no exception. The first Boeing aeroplane design was called the B & W, for Boeing and Westervelt, the designers. The second and third were both Model C, and the fourth was the EA. In 1925 a numerical designation system was adopted starting with Model 40 and is the system used throughout this book regardless of secondary manufacturer designation or military designation used. The new system was applied retroactively to the earlier models. The basic C design became Models 2 and 3 while subsequent C-variants became Model 5. So well had the C designation become established, however, that it has been retained for official historical reference to that model.

Once firmly established, the numerical designation system was applied to *all* designs as soon as they went down on paper, with the result that there are sometimes great numerical gaps between two consecutive Boeing designs that enter service. These gaps have been further increased by assigning Boeing model numbers to other than aircraft designs. In 1930, numbers 104 to 199 were reserved for Boeing-designed aerofoils. The 500 series was originally assigned to the Boeing gas-turbine engine in 1947 and later to the Industrial Products (later Turbine) Division, and the 600 range was assigned to the missiles of the Pilotless Aircraft Division.

Inconsistencies in the application of this system are responsible for the format of this book. In some cases, the basic model number applied to all variants of a single model, notably the long-lived Models 15, 40, and 299. In other cases, however, each variant of an original design was given an entirely new model number. The outstanding example is the famous fighter family of Chapter 5, which started with Model 83 and ended with Model 256. There were many other design studies and actual aircraft of entirely different design that carried intermediate numbers within this range. The Model 15 was an interesting case in that Army versions were Model 15 to 15D, but Navy versions were Models 15, 53, 54, 55, and 67. In some cases, Boeing assigned its own model numbers to 'outside' designs that it built while in others it did not. Since it is desirable to present closely-related

models or continuing series together, it has been necessary to group certain aircraft in this book by design families or periods of time rather than by sequence of model numbers.

Boeing made exceptions to sequential model designations when absorbing other companies with established product lines that remained in production under the original designations. Examples are former Stearman (later Wichita Division) models produced from 1939 to 1945 and Vertol models produced since that firm was purchased in 1960.

In the days before standardization of military designations, the armed forces bought and used aircraft under the manufacturer's own model designation, while civil customers and airlines have always used the factory designation. In many cases, an aeroplane became famous under a military designation, and is consequently known to the public almost exclusively by that designation. Sometimes, especially with the World War II military types, the aircraft were referred to in the factory by military rather than factory designation. The manufacturer's nameplate, carried in every aeroplane, uses the factory designation while models purchased by the military carry a second military nameplate with the military designation. Because of this dual designation of a single model, all the entries in this book are presented both by Boeing model number and the service or other designation.

MILITARY MODEL DESIGNATIONS

Shortly after World War I, the US Army and Navy, principal customers for Boeing military aircraft, adopted systematic but different aircraft designation schemes. These are described here briefly to familiarize the reader with the symbols used. Specific identification of most symbols used appears in the text under the appropriate aircraft heading.

US Army (Later US Air Force) Designations

In 1920, the Army adopted a Type-Model-Series system that told much about an aircraft. As originally adopted, the initial letter of the designation PW-9D indicated the type of aircraft as PURSUIT. The second letter indicated that it was a WATER-COOLED engine, while the 9 indicated that it was the 9th model of the PW type. The D indicates the fourth variant, or improved version, of the original PW-9 model. The system was simplified in 1924 to delete the second letter, and the series started anew with the Curtiss P-1. Another change was made at that time to indicate the status of the aeroplane. The letter X was added to the designation as a prefix to identify an experimental, usually prototype, model. Sometimes new features were tested on a later series of an established model and justified an X-designation, as XP-12G. In 1929, the prefix Y was adopted to indicate the service test status of a new model ordered into production in limited quantity for evaluation. If the aircraft were procured with F-1 funds instead of from the regular service appropriations, the prefix was Y1, as Y1B-9A. The letter Z was adopted to designate obsolete types still in service. Usually, X and Z

prefixes were permanent while Ys could be deleted upon completion of the service test. Until the end of WW-II, the series letter seldom changed during the experimental stages of aircraft development unless significant changes were involved. For example, there was the XB-29, and the initial production B-29. A significant structural change resulted in B-29A. Since WW-II, the series letter A has generally been used by Army/USAF to designate the first *production* version of the model.

Before WW-II, practically every minor variation in armament or structure resulted in a new series letter. These changes became so numerous in WW-II that the Army adopted a block number system to keep track of minor changes without changing the series letter. There were, for example, B-17G variants from B-17G-1 to -135. This does not mean that there were actually this many variations. The numbers were assigned by the Army in blocks of five, starting with -1, then -5, -10, -15, etc. The intermediate numbers were saved for changes made at modification centres. A B-17G-10 with such change could have become -11 or -12.

In 1942, when a number of major firms were building the same type of aeroplane under a single military designation, the Army added manufacturer's code letters to the basic designations to identify the actual manufacturer. Boeing-built B-17G-10s were B-17G-10-BO, for example, while Douglas and Vega-built models were B-17G-10-DL (for Douglas Long Beach Plant) and B-17G-10-VE, respectively. It should be noted that the block numbers assigned to the three B-17 builders did not match; a B-17G-10-DL was not an exact duplicate of either a B-17G-10-BO or a B-17G-10-VE. Boeing-built B-29s were B-29-BN for those built in the Renton plant (which had been built for the Navy) and B-29-BW for those built at Wichita. B-29-MOs were built by Martin and B-29-BAs by Bell.

Usually, the military designation is assigned only after an existing aeroplane is purchased or a contract is signed for the design and construction of a new one. In rare exceptions a regular military designation was assigned to an aeroplane that was still company-owned but under test by the US Army on a Bailment Contract, as was done with the Boeing Model 202 tested as the XP-15.

In the early 1930s the designation problem was complicated by the apparent use of two separate Army designating systems. In addition to the standard Type-Model-Series system in regular use there was another, with numbers starting at 900. This system was specifically for company-owned aeroplanes submitted to the Army for Bailment testing. The number was prefixed by two letters, X-for-Experimental and another identifying the type of aeroplane, as B-for-Bomber, P-for-Pursuit, etc. (XB-901 Boeing Model 215, XP-936 and XP-940 for Boeing Models 248 and 264). Such aeroplanes could carry either civil or military markings and colour schemes.

Army and Air Force Redesignations

Changes made to improve a military aircraft in its early growth years are closely co-ordinated between the manufacturer and the military. Resulting

changes in military designation are usually matched by corresponding changes in factory model numbers, as B-47A and B-47B being Boeing Models 450-10 or 450-11, etc. As the aeroplane becomes obsolescent or the military assigns it to other uses, changes are frequently made in the series designation and sometimes to the basic type designation. The manufacturer may or may not be invited by the military to undertake the modifications. Examples are the changes made by Boeing soon after the initial delivery of B-50Bs to adapt them for special missions at Air Force request as RB-50E, F, and G. Boeing model numbers did not reflect these changes, which were largely of equipment. Later, in the declining years of the series, the Air Force had the same aeroplanes converted to tankers by another contractor. The KB-50 tanker conversions had no effect on the original Boeing designations, but the earlier conversion of B-29s to KB-29P tankers by Boeing resulted in a revised Boeing designation of 345-3-20. In the B-50 example cited, all changes still recognized the original bomber designation of the aircraft, and the change of mission was indicated by a revised series letter or a prefix to the basic type designation. Prior to 1948, significant changes made to an aeroplane by the Army to suit it for a different mission usually resulted in an entirely new designation, as F-13 for a photo-reconnaissance conversion of the B-29. Since the changes were often made at military modification centres, the manufacturer's designation was not affected even though the factory may have been advised. The military redesignation problem was largely eliminated in 1948 when special-purpose prefixes were added to the basic aircraft designation, and the F-13s became RB-29, the R indicating the photo-reconnaissance status of the basic B-29.

Another cause of redesignation by the military, especially before 1948, was miscellaneous test work in which a particular aeroplane was used either for experiments intended to improve the basic design or as a convenient test bed for new equipment that had nothing to do with improving the effectiveness of the aircraft in which it was installed. Since such changes made the aircraft significantly different from its contemporaries, a designation change was justified, especially in the case of standard service models subject to frequent modification and maintenance through the Technical Order (T.O.) system. In an extreme case, all examples of a particular model might be ordered to be grounded until a certain operational safety requirement was met. A standard aeroplane withdrawn from normal service for a test programme to which this requirement would not apply would be subject to the same grounding order, thereby delaying the programme. Redesignating the aircraft from B-29A to XB-29G, for example, made it a different aircraft, no longer subject to T.O.s affecting all B-29As. At other times, the designation of a single test aeroplane was changed several times merely to identify different test configurations. The first P-12E (Boeing Model 234) became XP-12E soon after delivery to the Army, then became, successively, YP-12K, P-12L, YP-12K again, and finally reverted to standard configuration and was redesignated P-12E, all without affecting the Boeing model number. This particular redesignation

problem was resolved in 1955 by adding special test prefixes, J and N, to the basic aircraft designation to proclaim its special status and permit many minor variations without the need to change the series letter every time.

Unfortunately for historians, many series redesignations made by the military in a planning stage were never used or were of such short duration that the special configuration did not become well known. Once assigned, even though not used, these designations were not reassigned. Since many had nothing to do with improving the basic aircraft, the manufacturer was not advised and therefore has no official knowledge of many of the military designations applied to his own product after it left the factory.

US Navy Designations

The Naval aircraft designation system adopted in 1922 was similar to that used by Army in basic designation by type, but the model was determined by the number of designs of a particular type procured from a given manufacturer. The type letter F designated a fighter while the manufacturer's letter B identified Boeing. The FB-1 was the first Navy fighter procured from Boeing. Variants of this first model were FB-2, -3, etc. An entirely new fighter model, Boeing's second for the Navy, was F2B-1 (actually XF2B-1 for experimental. Navy adopted the X prefix in 1927). This system did not always specify the actual designs, or the number of models actually produced. The designations are assigned in sequence of contracts, which are not always completed. There was to have been an OB-1 observation aircraft, which was contracted for but not built, while O2B-1s were actually delivered. The Naval designs for one manufacturer are re-designated when produced by another. The PBY-5 (PB for Patrol Bomber, Y for Consolidated) was built by Boeing as PB2B-1 because a Boeing-designed patrol bomber, the XPBB-1, had already been built.

Royal Air Force Designations

The Royal Air Force, which used a number of Boeing-built aircraft during and after WW-II, used neither manufacturer's model designations nor the equivalent US military designations as did some other Air Forces. The RAF used its own name system with variants indicated by Mark numbers. The US Army B-17C was the RAF Fortress I, the B-17G was Fortress III, and the B-29 was Washington I.

POPULAR NAMES

While most aircraft manufacturers assign actual model numbers to their products, many are marketed under a popular name rather than a number. Boeing built its first named aeroplane, the Model 200 Monomail, in 1930, but did not make a practice of naming every subsequent model. The name Flying Fortress was copyrighted for the Model 299/B-17 series that originated in 1935, while the name Clipper applied to the Model 314 flying-boats of 1938/41 fitted them into Pan American Airways' established fleet

of variously-named Clippers. During WW-II the military encouraged the use of popular names rather than specific numbers for general reference to a particular model, ostensibly as a security measure so that unauthorized persons could not determine the production or development status of a particular model that would be indicated by a designation like B-17G. Manufacturers were given the option of choosing the names themselves, subject to official approval, or the Aircraft Production Board picked one for them. This system was not too well received by people closely associated with the aircraft, and actual model designations with accurate series letters were often used.

POWER PLANT DESIGNATIONS

The engines in civil aircraft use the engine manufacturer's own name or model number, as did military engines until 1926. At that time, a Type-Size-Series system similar to Army aircraft designations was adopted by both services. A letter identified the type, as R-for-Radial (air-cooled) and V-for-Vee (liquid-cooled). The size was indicated by the displacement to the nearest 5 cu in. Series was originally designated by letter, as V-1150C for a third military variation of the Curtiss D-12, a 12-cylinder Vee type of 1,150 cu in displacement. This was changed in the early 1930s to a numerical suffix assigned in sequence of development. 'Even' dash numbers indicated Navy engines while 'odd' dash numbers indicated Army, as R-1340-9 for an Army version of the Pratt & Whitney Wasp radial. Inter-service transfers of aircraft and/or engines resulted in Army aircraft carrying Navy engines, and vice versa. In some cases, letter prefixes were used to indicate experimental status or special features, as G for geared and S for supercharged. This Type-Size-Series system is still in use for reciprocating (piston) engines.

The advent of gas-turbine engines late in WW-II started a new designation system based on type of engine and sequence of procurement. Turbojet engines received a J type designation while turboprop engines were identified by the letter T in the same line of numerical progression. The Boeing Model 502 gas-turbine as used in Navy helicopters became the T-50. When several manufacturers produce the same engine, a letter is added to indicate the fact, as J57-P for the J57 built by Pratt & Whitney, the designer, and J57-F for the same engine built by the Ford Motor Co. Water injection is indicated by the suffix letter W, as J57-P-59W. Commercial designation for the J57 is JT3C. The improved turbofan version is JT3D. One military equivalent of the civil fan engine uses an entirely new designation, TF-33, instead of another variant of the basic J57 designation.

MANUFACTURER'S SERIAL NUMBERS

Every manufacturer applies serial numbers to his aircraft to indicate sequence of production, either within a particular model series or with

respect to total factory output. With aircraft in production undergoing constant improvement, the serial number (generally called constructor's number or c/n by aircraft data enthusiasts to distinguish it from the military serial number) becomes very important in determining whether a particular machine was built before or after a certain change was incorporated. Boeing plants in the State of Washington are currently applying c/ns that count backward to No. 1, the first B & W of 1916. This is not a true indication of overall Washington production, however, as 1,584 B-29s were built at Wichita during WW-II with Seattle c/ns.

An entirely different system was in use by the Stearman Aircraft Company before it became a Boeing Division. Serials were assigned within the basic model number, but were rather inconsistent. Some models, as the 70, 75, and 90, started the numerical count at zero, as 70000, 75000, and 90000. Others started with the figure one, as 73001, 76001, and 20001 for Models 73, 76, and 200 (XL-15), respectively. When production of B-47s and B-52s was undertaken at Wichita in the 1950s the old Stearman system was used, resulting in production of a single model under both the Seattle 'total production' system and the Wichita 'total by models' system. Wichita's first B-47 (Model 450) was 450001 and its 444th B-52 (Model 464) was 464444. The Vertol Division uses its own serialization systems as did the original Boeing Aircraft Company of Canada and the present Boeing of Canada which acquired De Havilland in 1986. Bomarc and Minuteman missiles, while carrying aircraft-type Air Force serial numbers, do not carry c/ns which are integrated into either of the basic Boeing Airplane serial number systems.

In this book, the expression c/ns: 88/198 indicates Boeing serial numbers 88 to 198, inclusive.

MILITARY SERIAL NUMBERS

Both US military services use their own serialization systems, which are entirely separate from c/ns and are used for operational identification, maintenance, procurement, and technical-change effectivity.

Navy Serial Numbers

After trying aircraft serialization schemes based on numbers within a specific type as used on ships, the US Navy backed up in 1917 and established a system that numbered aeroplanes consecutively from No. 1 of 1911. The number was prefixed with the letter A-for-Aeroplane from 1917 throughout the 1920s. The total reached 9999 in 1934, so was restarted. Increased rate of procurement threatened to reach the second 9999 by 1940, so the system was short-circuited at 7303 to prevent duplication of late numbers in the first series. The third series started with five digits, 00001, which has now grown to six digits. It passed 162782 in 1986. Navy serials were originally painted in large figures on the fuselage or hull, then were standardized on the vertical fin in small figures forward of the model

designation. For security reasons, they were reduced to almost illegible size during WW-II, and now appear on the fuselage under the forward edge of the stabilizer and either in full or as only the last four digits on each side of the vertical tail.

Army/Air Force Serial Numbers

Army serialization began in 1908 and reached the 68000s by 1921. At that time, the system was changed to a fiscal year basis, aircraft 22-1 being the first one ordered in the fiscal year of 1922 (July 1, 1921, to June 30, 1922). This system is still in use. The Army serial appeared in various forms on both sides of the fuselage during the 1920s, but was confined to the Technical Data Block on the left side of the nose after 1931. After Pearl Harbour, it reappeared in large figures on both sides of the tail, but without the first digit of the fiscal year. B-17F 42-3050 showed the tail number as 23050. No conflict with a later aircraft 52-3050 was anticipated as military aircraft were not supposed to last ten years. When some did, however, the duplication of serials was taken care of by the prefix O, meaning 'over ten years old', as O-559595 for YC-97A 45-59595. Since the last four digits of the serial were used as radio call letters, short numbers were built up to a minimum of four digits (five since 1958). The tail serial number of XB-29 41-2 thus became 1002 while B-52H 60-1 has the tail number 00001.

In May 1917, US military aircraft of both services adopted the three vertical tail stripes of France and Britain and the distinctively American star-in-circle wing marking. The star was abandoned briefly in 1918 and 1919. The Army used the vertical stripes until the end of 1926 but the Navy and Marines retained them until WW-II, as shown on this Boeing F4B-3. (*US Navy Photo*)

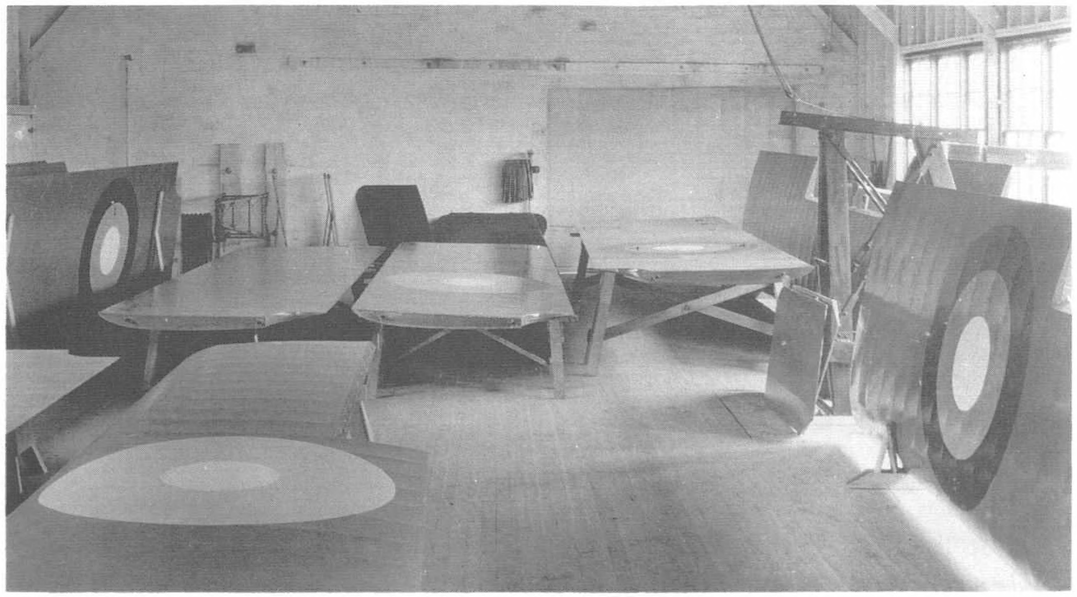
MILITARY MARKINGS AND COLOURING

Both US military services and the Royal Air Force had standard colour schemes that varied widely over the years for different classes of aircraft and for different missions. This subject is worthy of a book by itself, and remarks on the colouring of individual Boeing-designed aircraft are confined to the appropriate aircraft descriptions in this book.

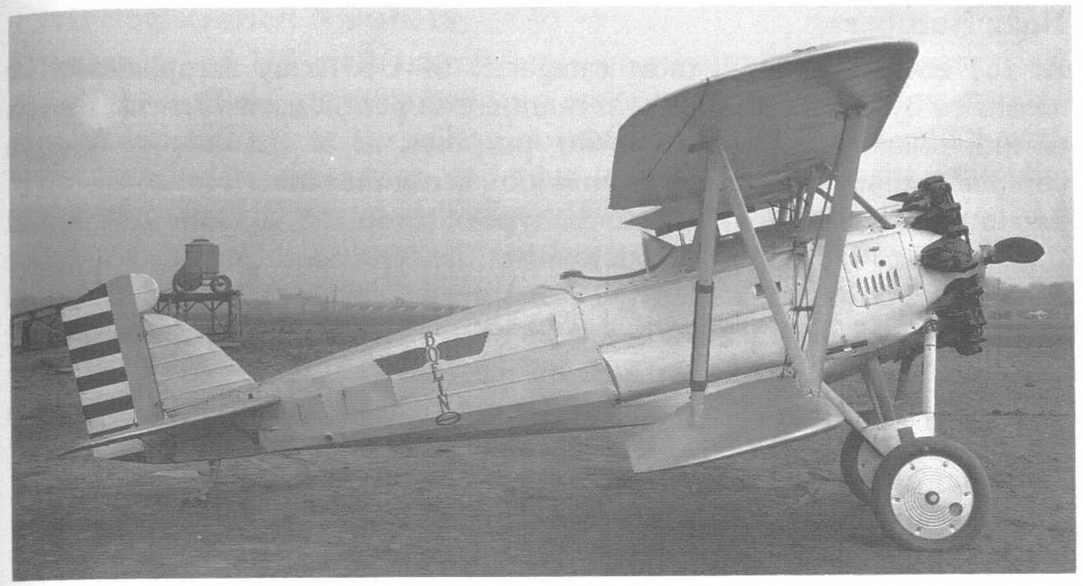
US National Markings

Over the years, there have been many changes in the application of national markings to US military aircraft. A sharp student of the subject can tell with a fair degree of accuracy just when a particular aeroplane photo was taken merely by a careful study of the markings. To save discussion in the text, the important changes in these markings are described here.

Shortly after US entry into WW-I, standardized national markings were adopted in keeping with the schemes then in use by the major allies. On May 17, 1917, wing markings were adopted in the form of a white star on a blue circle, with a red circle in the centre of the star. The tail marking duplicated that of France and England, with three vertical stripes of red, white, and blue, in equal width, on the rudder. The red was at the trailing edge. In January 1918, a change was made from the star to a tricolour circle that was more in keeping with the circle markings of the other allies. The colour arrangement was that of the former Imperial Russian forces, a red outside circle, a blue, and then a white centre. The order of rudder stripes was reversed at the time to place the blue at the trailing edge. This marking remained official until August 1919, at which time the star and the tail stripe order of 1917 were readopted.



Wing panels for Boeing C-series Navy trainers in the paint shop for application of the short-lived circular wing insignia of 1918–19. (*Boeing Photo*)



The XF3B-1, a Boeing-owned test aeroplane, was a demonstrator for the new tail stripe arrangement that Boeing developed in 1926. The horizontal stripes duplicated the 13-stripe pattern of the American flag. The US Army adopted this arrangement for its aeroplanes in November 1926, and retained it until May 15, 1942. Note also the early application of the 'Boeing Bug' trademark. (*US Navy Photo 4977*)

The tail stripes remained in use by both services until the end of 1926, at which time its use became less frequent by the Navy, which began to use solid-coloured tail surfaces to identify squadrons of aircraft by unit, assigned aircraft carrier, or station. In November 1926, the Army adopted a new marking developed by C N Monteith, then chief engineer of Boeing, which retained the vertical blue stripe of the standard marking but substituted thirteen alternating horizontal red and white stripes, similar to those on the American flag, for the other two vertical stripes. The Army used this marking on all models until March 1941, when it was deleted from camouflaged types, and did away with it altogether on 15 May 1942.

Since 1917 the star (or circle) marking had been used on both wings only, but with the readoption of camouflage for Army and Navy aircraft in 1941, the marking was unbalanced by being used on the upper surface of the left and lower surface of the right wing only and on each side of the fuselage. By the middle of 1943 this arrangement had been standardized for all Army and Navy aircraft, camouflaged or not.

A major change was made in May 1942, when the red centre circle was eliminated because of similarity to the Japanese aircraft marking. In July 1943, another change was made to increase the visibility of the marking. A white rectangle, equal in length to the radius of the basic circle and having a height of half the radius, was placed on each side of the circle and the whole was surrounded by a red border having a width one-eighth of the radius of the circle. Two months later this red border, again because of similarity to Japanese colour, was changed to blue. No further changes were made until January 1947, when a red bar was added to the centre of each white rectangle. This marking is still in use.

Buzz Numbers

At the end of WW-II, most categories of US Army aeroplanes were identified by symbols called 'buzz numbers' to permit positive identification of individual aircraft for reporting purposes, as in the case of filing a complaint about a low-altitude 'buzz job', hence the name. This consisted of two letters, the first to designate the type of aeroplane, as C for Cargo, and the second to identify the model within the type, as S for the C-97. The symbol was completed with the last three digits of the aeroplane serial number. As the likelihood of buzz jobs being performed with heavy aircraft decreased, the use of the symbols on these aircraft decreased in the early 1950s and was used mainly on fighters until phased out by 1970. Symbols assigned to Boeing-designed aircraft in the post-WW-II years were:

BA	B-17 (later assigned to B-57)
BF	B-29
BK	B-50
BL	XB-44
CS	C-97
FG	F-13 (to RB-29 as BF)
LE	L-15 (shared with L-6, L-18)
TF	PT-13

CIVIL COLOURING AND MARKINGS

The colour schemes for civilian aircraft were, of course, an individual matter. Each airline preferred a standardized scheme for all of its machines as a matter of public identification, while private owners could specify their own colouring for a price or take whatever pattern the factory used.

Factory and Airline Colouring

For the period 1928/32, Boeing had a distinctive colour scheme of its own for factory-test machines and the Boeing-built aeroplanes used on the Boeing Air Transport system. With minor variations in details, this consisted of a light French grey for basic colouring, with International orange for the top surface of the upper wing and sometimes the bottom of the lower wing. Fuselage and tail were initially trimmed with a special dark green known as Boeing green, but eventually the fuselage became all green in some subsidiary organizations. The introduction of the all-metal Model 247 into airline service in 1933 ended factory application of the Boeing colours in favour of anodized aluminium (247 only) and later polished aluminium. Fabric-covered aircraft remaining in service retained the grey-orange-green, notably the machines at the Boeing School of Aeronautics which flew until the end of 1941.

Civil Registration Numbers

Registration of US civil aircraft was not required until January 1927, although unofficial attempts had been made earlier to use the international system adopted by the Versailles Convention of 1919, which used a single letter to identify the nation and four letters to identify the individual aeroplane. The US system of 1927 used two letters, the letter N assigned to the US at Versailles, followed by another letter to indicate the status of the aeroplane, X for experimental, R for restricted, and C for commercial or fully licensed. These were followed by a sequential number to identify the aircraft. If no letters preceded the number, the aircraft was merely registered and was not licensed. When the numbers passed 10,000 in 1929, they were shortened to one, two, or three digits with a suffix letter added. At present, the registration number can consist of up to four digits and one or two suffix letters or five digits. It has become quite common in the jet age for airlines to use their initials as the suffix letters, as 707PA for Pan American. The registration does not change with the status of the aeroplane. The prototype Model 314 Clipper, NX-18601 became NC-18601 upon certification. The second prefix, or status letter, was deleted in 1948.

When American-registered aeroplanes were sold out of the country their American registrations were cancelled and those of the new country applied. In some cases where the same aeroplane was later purchased by an American owner it was able to regain its original American registration. Usually, however, a later registration was assigned.

Registration numbers are usually assigned in blocks to a manufacturerer, and a single production run of aircraft will have consecutive registrations, usually progressing in step with the c/ns. The Boeing Model 247s were registered NC-13300 to 13370. In the jet age it became common for the airline, rather than the manufacturer, to apply for the registration numbers, preferably in a consecutive run of standard numbers or a selection of numbers and letters with special significance to the airline, as N707PA/712PA for Pan American's first six 707s.

Superstition entered the picture here. Because some passengers might be hesitant about flying in an aeroplane with the number 13 on it, the 713PA registration was skipped, continuing with 714PA/730PA.

From 1927 to the late 1950s, the registration was applied to the upper right and lower left wings, and to each side of the fin or rudder. Since then, it has appeared in figures a foot high only on each side of the fuselage, which is hardly large enough to be read beyond the wing tip of a large aeroplane.

Most other nations adopted the Versailles scheme of 1919. Under this, Great Britain was identified by the prefix G, while the Dominions used the first two following letters as sub-designations, as G-CA – for Canada. Increasing aircraft registration soon exhausted the combinations available with the two remaining letters, so the system was revised to a two-three arrangement in 1929, with Canada receiving its own prefix of CF. This international marking first appeared across the full span of top and bottom wing surfaces and on both sides of the fuselage, but since WW-II has

tended to follow the old American pattern of small letters on one wing surface only and each side of the vertical tail or the fuselage. Some follow the current American practice of fuselage or fin markings only.

In the jet age a problem of individual aircraft identification arises when the unusual phenomenon of several different aeroplanes carrying the same registration number is seen. This is done to fill a need for temporary American registration for shakedown or minor test flights of an aeroplane bought by and already registered in another country. Rather than go through all the paperwork necessary to assign American registration to an aeroplane that needs it only briefly, the FAA issued to Boeing (and to other aeroplane exporters) a few 'open' numbers that did not apply to any specific aeroplane but could be used for local area identification of a whole series of unregistered aeroplanes. In use, these are similar to the 'Dealer Plates' issued to automobile dealers for use on demonstration cars or cars being transferred to different locations before a new owner obtains new plates in his own name.

The 'Dealer Plate' short-use registration N1786B is seen here on the first and, although not visible here, was also on the third unfinished Model 737s on the Renton preflight line. This photograph could not include a nearby Model 727 carrying the same number. (*Photo by Peter M Bowers*)

No confusion results because only one such aeroplane is in the air at a time. In most cases where aeroplanes already carrying non-American registrations are flown with their own national markings, the temporary US registration is displayed on cards in the cabin windows.

A Model 737-2C3 of Cruzeiro, with Brazilian registration PP-CJN, seen flying with temporary US registration N8285V carried on cards in six rear windows. Note that Brazil is one of the very few countries still carrying the aircraft registration across both wings. (*Boeing Photo P-50197*)

In cases where an aeroplane destined for another country requires extensive testing in the United States, that aeroplane receives regular US registration reflecting current Boeing ownership and the appropriate data as to c/n, etc, for as long as it is needed. In such cases, the American registration is painted on the aeroplane properly, sometimes with the assigned registration of the purchasing country also appearing.

These 'dealer' numbers are also widely used on unpainted Boeing aeroplanes in outdoor work areas of the factory airfields, with the same number painted on several aeroplanes, even of different models, at the same time. The number is used in communication with the airport control tower when it is desirable to move one of the aeroplanes to a different place on the airport or even for a short test flight or ferry flight to another airport for further work or final painting.

It will be noted that the author has avoided using the word 'foreign' in referring to aeroplanes of other than American registry and ownership in the

A 747-124 with a complicated history. It was delivered to Continental Airlines, then sold to the Imperial Iranian Air Force, which sold it back to Boeing. Boeing then leased it to AVIANCA, where it carried Colombian registration HK-2000 applied to the fin by Boeing. For pre-delivery testing in the USA, the aeroplane also carried US registration N747AV. (*Boeing Photo P-51790*)

preceding paragraphs. This is in keeping with a Boeing policy under which employees are not to refer to such aeroplanes as 'foreign'. Rather, they are to be called 'non-American'.

One employee carried this good intention a bit too far when translating standardized lavatory placards into another language – one appeared as DO NOT THROW NON-AMERICAN MATERIAL INTO THE TOILET.

The great quantity of Boeing jet airliners, with well over 6,000 built between 1957 and 1988, makes it impractical to list each civil-registered Boeing jet aeroplane by its original and subsequent registrations in an appendix as was done in previous editions of this book. Instead, the initial registrations, along with c/ns and customer data, are presented at the back of this book in tables for each designated model and sub-model, as 727-100, 727-200, etc.

SPECIAL TEST MARKING

Most Boeing prototype aeroplanes from the XB-52 on and others diverted to special test programmes carried a distinctive temporary marking on the upper fuselage aft of the wing. This was a target for a photo-theodolite instrument used to track and measure take-off and landing runs from a fixed ground station. The target presented a fixed aiming point on the aeroplane for instrument sighting.

On the XB-52 and up to the 367-80 and KC-135s this marking consisted of a black square backing a white cross. The small black squares that this marking presented had an interesting consequence. Since the lower two black squares looked like windows in certain photographs, an artist misinterpreted them as such and expanded them into a whole line of windows on a B-52 painting that he made to illustrate a fiction story in a major American magazine.

Later Boeing prototypes had the marking reduced to a four-section square, with the black and white squares matched diagonally. On some light-coloured fuselages, only the diagonal black squares were used.

The YB-52 with an elongated photo-theodolite target painted on the fuselage behind the wing. It is easy to see how the two lower squares could be mistaken for windows. (*Boeing Photo P-12775*)

The first Model 737, with a revised form of the photo-theodolite target, a quartered black-and-white square painted on the fuselage above the wing. (*Boeing Photo P-41218*)

BOEING TRADEMARK

In 1926 Boeing adopted a trademark that eventually became known as the 'Boeing Bug'. This was also developed by Monteith, and consisted of the vertical word BOEING, with wings spreading from the letter O. The G was expanded horizontally so that it made the whole device resemble the plan view of an aeroplane with feathered wings. This was used in company advertising, on the aircraft nameplates, and for a few years was painted on the fuselage of company-owned aircraft.

The original Boeing Bug, used as the principal Boeing trademark from 1926 to 1942, has seen but limited use since World War II.

Upon the establishment of the Boeing Air Transport System in 1927, this copyrighted Boeing emblem was incorporated into the insignia of the new airline. It appeared against a white circle on each side of the fuselage, with the words AIR TRANSPORT INC. in the bottom half of a narrow outlining circle set off from the basic circle by a blue line. The whole was surrounded by a red outline. Factory test and demonstration machines merely used the word SEATTLE at the bottom of the outer circle.

For a short period in 1928 and 1929, the original Boeing Air Transport System used a supplementary and highly symbolic trademark in keeping with its advertising slogan, the Bee Line. This consisted of a straight line, symbolic of the straight-line advantages of point-to-point air travel, with the world SAN FRANCISCO at one end and CHICAGO at the other. A large stylized letter B, for Boeing and Bee, and shaped like the head of a comet to indicate the speed advantage of air travel over ground methods, was superimposed on the line. The word LINE in smaller letters was drawn over both the letter B and the actual line. The length of the line varied on different size aeroplanes, but the lettering remained the same size.

The short-lived Bee-line insignia of the San Francisco – Chicago route of Boeing Air Transport, 1927–28.

As other airlines were absorbed into the Boeing System, the Boeing trademark was retained in the circle and the name of the particular airline was added on a line flanking the circle. This lettering was eventually backed by a white rectangle. When the Boeing Air Transport System became United Air Lines, the words UNITED AIR LINES replaced the individual airline names flanking the circle, but the basic Boeing System trademark was retained. In 1934, when Boeing withdrew from the airline business, the Boeing Bug was replaced in the circle by a silhouette map of the United States that showed United's routes.

Use of the Boeing Bug was discontinued as a company advertising trademark early in WW-II because the vertical composition was considered unsuitable for use in advertising copy. It was replaced by the word BOEING in script lettering in advertising and on company documents, letterheads, and aircraft. However, because of the large capital letter B and the upward slant of the entire word, this trademark too was considered to have too much height for maximum effectiveness. A new slanted block lettering, called 'Stratotype' because it was developed specifically for application to the

Script trademark of 1943–47.

prototype Model 377 Stratocruiser, was originated by company artists in 1947. Laid out horizontally, the word BOEING in this style has been the official company trademark ever since.

Only vestiges of the Bug remain in use in 1989, mainly on employees' service pins and on the uniforms of such specialized employees as flight line attendants and guards. The jackets and overalls of laboratory technicians and shop personnel carry the Stratotype trademark across their backs.

'Stratotype' lettering developed in 1947 is now the principal Boeing trademark.

NAMEPLATES

Essential data on a particular aeroplane, such as the name and address of the manufacturer, the basic model and sub-series, the serial number, the date of manufacture of the specific airframe and sometimes such additional data as make, model, and power of engine are incorporated on a metal nameplate affixed to the aircraft in a location where it is not only available for ready reference, but, at government insistence, in a spot that can be expected to survive a major crash.

Manufacturer's nameplates

These have taken many forms over the years, and have often been patterned after distinctive company trademarks. In the years immediately preceding WW-II the Manufacturers' Aircraft Assocation sought and largely achieved a standardization of manufacturers' nameplates among the member aircraft firms. In addition to the basic information covering the aircraft, the plate contained a statement to the effect that the machine was built using patents covered by the cross-licensing agreements of the Association.

Certificate (ATC) to the manufacturer for the particular model that has been approved. Unless major changes are made that call for retesting, the model retains the same ATC number throughout its production and service life. The Boeing Model 40A received ATC No. 2 on July 26, 1927, but was given ATC No. 27 in February 1928, after installation of a larger engine that converted the original Model 40A to 40B.

All ATC'd aircraft and some Category 2 types carried the letters NC in front of their prefix registration numbers until 1948 to indicate their status. Aircraft with no prefix letters to the registration number, common in the late 1920s, were unlicensable types that were only registered and were flown under restrictions that limited their field of operation and kept them out of the paying-passenger trade. After deletion of the second letter from the registration prefix, the actual status of the aeroplane, whether Experimental, Limited, or Restricted, was painted near the entry door or cockpit to inform the occupants of its non-standard status as they came aboard.

Government inspectors make sure that only approved deviations are made from the original certificated model before licensing later production aeroplanes. From 1927 until shortly after WW-II, aircraft intended for commercial use but which did not meet the full requirements for an unlimited licence were issued Category 2 certificates, sometimes called Memo Approvals. These permitted limited commercial operation and were usually issued to small-production batches or to commercial prototypes that were still useful aircraft although not in regular production. Changes made by the manufacturer while the particular model is still in production are usually incorporated in the existing ATC, but changes developed by individual owners or aircraft maintenance shops receive Supplemental Approvals. These authorize specific modifications under the original ATC but are issued in the name of the applicant or the organization performing the actual work.

A special Category III saw limited use in the late 1920s. This applied to aircraft built before 1927 which had commercial potential but did not qualify for an ATC. These were approved on the basis of individual aircraft inspection. Boeing models qualifying for Category III approval included the single B-1 of 1919, surplus US Navy HS-2Ls, and several DH-4M-1s released by the Army to other government agencies that found their way from there to civil owners.

Originally, ATC approvals were issued sequentially from FAA engineering offices in Washington, D.C., the numbers reaching almost 900 shortly after WW-II. The highest issued to a Boeing aeroplane was ATC 812 for the Model 377 Stratocruiser in 1948. After that time, approvals were issued sequentially by the numbered FAA region in which the aircraft was manufactured, as 4A-21 for the Boeing Model 707-100, the 21st aircraft certificated in FAA Region Four. The system underwent a slight revision soon after, and the Model 727 received ATC-A3WE as the third aircraft certificated in FAA's newly-designated Western Region. The letter A indicates Airplane, as distinct from Glider (G) or Helicopter (H) approvals.

Chapter 1

THE BEGINNING OF BOEING

Like great oaks, great organizations often have extremely small beginnings. This is true of The Boeing Company, which is at present the oldest continually-operating airframe manufacturer in the United States and among the largest in the world in terms of personnel employed, dollar volume of business, and pounds of airframe produced.

The beginning was most informal. Two friends, in no way connected by business association, were discussing aviation as it existed in 1915 and came to the conclusion that between them they could produce an aeroplane that was better structurally and aerodynamically than the crude bamboo box-kites then being operated by exhibition pilots in the northwestern part of the United States. The individuals were William E Boeing, prominent Seattle timberman, landowner and yachtsman, and Conrad Westervelt, a Naval Officer assigned to a Seattle shipyard. The organization that these men established to carry out their ideas was originally an informal partnership, later a more formal corporation known as the Pacific Aero Products Company. This was soon to become the Boeing Airplane Company, then Boeing Aircraft Company, Boeing Airplane Company again, and finally, in the dawn of the Space Age and expansion of the aviation industry into space vehicles, missiles, and non-aircraft products, The Boeing Company.

The original Boeing factory, built on offshore piling in Lake Union in 1916, shown in use as a seaplane base circa 1930. The building is at present in use as a covered boat mooring, the floor having been ripped up to permit boats to be floated in.

The manufacture of Boeing aeroplanes began in a unique seaplane hangar-cum-factory located on the east shore of Lake Union, a large body of fresh water roughly two miles long and three-quarters of a mile wide in the heart of the city of Seattle, Washington. The building, often referred to erroneously as a floating hangar, was actually constructed above water level on piling driven offshore at the foot of Roanoake Street on the eastern shore of the lake. The impression of floating was conveyed by the sloping seaplane ramp that hid the piling from view, and was reinforced by the prevalence of houseboats and other floating buildings in the immediate area. Although used originally to house a Martin seaplane that Boeing had bought following his decision to undertake the construction of aircraft with Westervelt, it was constructed with the actual manufacture of aircraft in mind.

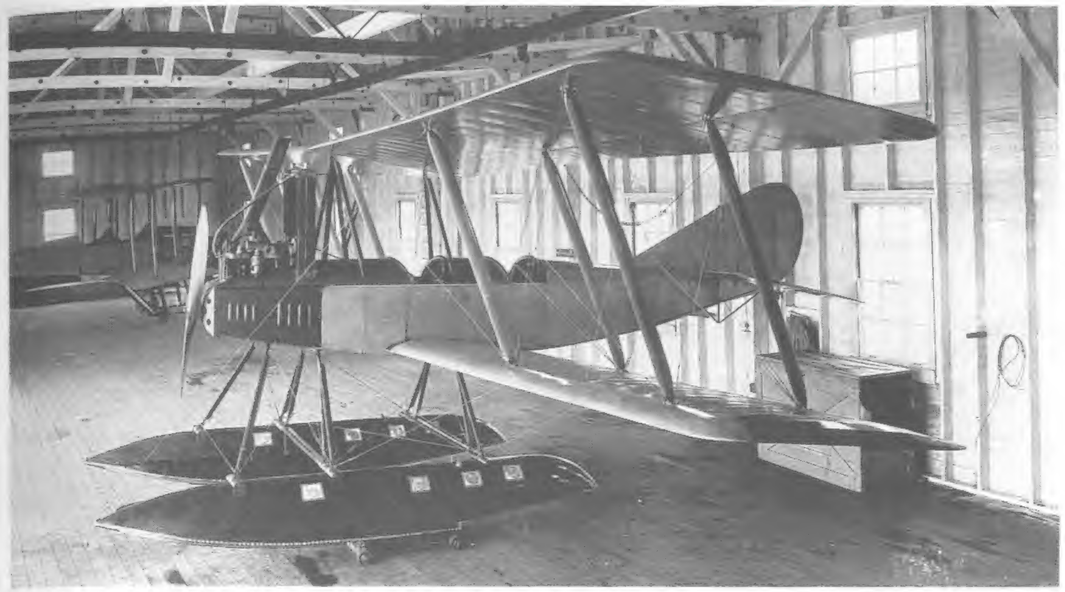
Design work on the new aeroplane began late in 1915. The Martin was a good example of the most up-to-date products of the contemporary American aviation industry, which was beginning to fall behind European industry because of the rapid advances being made under the pressures of what was then called the European war. Experience with the operation and frequent repair of the Martin also provided good first-hand knowledge of the aerodynamic and structural problems involved. It was more than a coincidence, therefore, that the first two aeroplanes built, called B & W for Boeing and Westervelt, bore a strong resemblance to the Martin.

Commander Westervelt was not on hand to witness the fruition of his labours, having been transferred to the east coast on Navy orders before the B & W made its first flight in June 1916. With the original partnership dissolved by Westervelt's departure, and the B & W aeroplane a demonstrated success, Boeing decided to establish a formal corporation for the specific purpose of manufacturing aircraft. Accordingly, the Pacific Aero Products Company was incorporated on July 15, 1916.

The two seaplanes were sufficiently successful to attract the interest of the US Navy, which was becoming aware of the rapid growth of military aviation in Europe and the need for expansion of its own air arm. While the Navy did not buy either B & W, it did encourage the development of a new model designed specifically as a trainer that could be used in the anticipated expansion of the Navy flight training programme.

With this encouragement, Pacific Aero enlarged its engineering and manufacturing facilities and undertook the design of two new models, a seaplane that could be used for sporting and commercial purposes as well as meeting the Navy requirements for a primary trainer and a landplane that was intended to meet Army requirements. After testing in Seattle, soon after the United States entered the war, the second and third examples of the new seaplane were sent by rail to the Navy test facility at Hampton Roads, Virginia. As a result of the trials, the Navy ordered a further 50 machines and the new Boeing Airplane Company, so named on April 26, 1917, became a large-scale manufacturer of aeroplanes by the standards of the day.

The lakeside hangar was entirely unsuited to such work so Boeing decided



One of the three Model 3 seaplanes fully assembled inside the original factory building, which also functioned as a hangar. In the background is Mr Boeing's original Martin seaplane in the process of coversion to a landplane. (*Boeing Photo P-19*)

to expand by setting up aircraft manufacturing facilities in the Heath Shipyard. This was a small yacht-building firm on the Duwamish River, south of Seattle, which had built the floats for the B & W. Boeing had acquired this firm some years previously as a result of other interests. Many of the existing buildings and much of the equipment proved suitable for the production of wooden aircraft parts, but additional facilities were established. A large final assembly building was erected after the Navy asked Boeing to build 50 Curtiss HS-2L flying-boats for the wartime

The main building of the former shipyard as it appeared when under guard on June 8, 1917. The original E W Heath lettering is still visible on the side of the building. (*Boeing Photo*)

The restored shipyard building, the Red Barn, (left) in its new location on Boeing Field as part of the Museum of Flight complex.

programme. The Lake Union hangar was retained as a flight operations base until after the war, when it was sold. It was used by several subsequent owners in support of seaplane operations until the early 1950s, when it was acquired by marine interests who converted it to a true boathouse, ripping up the flooring to allow boats to be floated in for covered moorage. This original Boeing building is still being used as a marina at the time of writing.

While some of the legal and financial affairs of the company were conducted from Boeing's office in downtown Seattle, which he used primarily for his other business interests, the administrative and engineering offices were located in the shipyard. Throughout the between-war years the plant remained essentially at the size that it had reached by the end of WW-I. No formal flying field was associated with the factory in its early years, but a small airstrip was established as a community airport on filled land at the base of the hills about half a mile northwest of the factory. Most initial testing of new models, however, was done either at the Sand Point Naval Air Station, on the west shore of Lake Washington, some 10 miles north of the factory, or at Camp Lewis, a large Army installation on broad plains well suited to flying, located some 50 miles south. All landplane testing from 1928 on was conducted from the new King County Airport, appropriately named Boeing Field, two miles to the southeast at that time. When the size and quantity of later aeroplane models taxed the existing facilities, an entirely new plant was built on Boeing Field. The former shipyard was subsequently identified as Plant 1.

After Plant 1 was closed in 1970, it was sold to the Port of Seattle and the land developed into a shipping terminal. The port donated the original shipyard building, the Red Barn, to the Pacific Northwest Aviation Historical Foundation (PNAHF). The building was then barged up the Duwamish river and placed on the southwest corner of Boeing Field. It was refurbished on that site and became the first building in the present Museum of Flight, one of the world's major aviation museums.

The first Boeing-designed aeroplane, the B & W of 1916, floating by the broad sloping ramp of the original factory-hangar. (*Boeing Photo P-14*)

MODEL 1 (B & W) – The first Boeing aeroplane design was a joint venture of William E Boeing and his assistants and Commander G Conrad Westervelt of the US Navy, who participated as a private individual while stationed in Seattle. The collaboration resulted in the designation of B & W for the two aeroplanes that were built to that initial design.

The first aeroplane was assembled in Boeing's new boathouse/hangar on Lake Union, after some components, including the pontoons, had been built in the shipyard. Construction was entirely conventional for the period, the structure being wood with wire bracing, all fabric covered. The engine was started by compressed air from a tank in the aft fuselage. The original control system was unique, a 'three-in-one', where forward movement of the control column worked the elevators, sideways motion moved the

The B & W being brought ashore. (*Boeing Photo 97169*)

The front and rear cockpits of the first B & W. Note sparse instrumentation. (*Boeing Photo*)

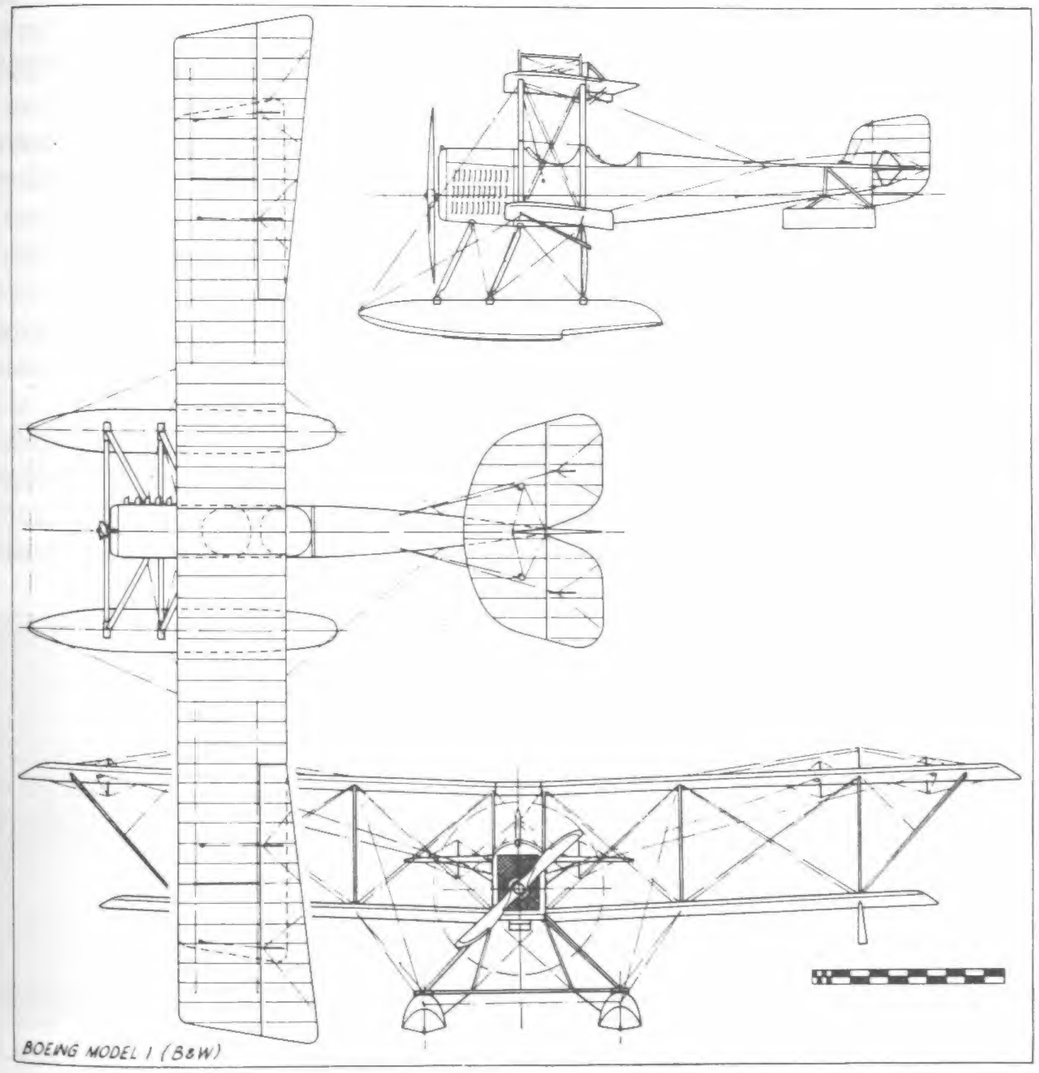
For demonstrations in Wichita, Kansas, and at air shows away from Seattle, the B & W 1A replica was fitted with wheels and brakes under the pontoons. These did not make the replica amphibious.(*Photo by Peter M Bowers*)

ailerons, and a wheel on top worked the rudder. There was no hand throttle; the pilot activated this with his right foot. This arrangement was quickly changed to the conventional Deperdussin control with rudder bar, while the original pontoons, which proved to be too small, were replaced with a larger and simplified design. The first B & W, named *Bluebird*, flew on June 29, 1916, and the second, named *Mallard*, flew in November. Both were sold to the New Zealand government in 1918 and were used as airmail carriers.

TECHNICAL DATA - B & W

Type:	Utility seaplane	*Empty weight:*	2,100 lb
Accommodation:	2 in tandem	*Gross weight:*	2,800 lb
Power plant:	Hall-Scott A-5, 125 hp	*Max speed:*	75 mph
Span:	52 ft	*Cruising speed:*	67 mph
Length:	31 ft 2 in overall	*Climb:*	700 ft/min
Wing area:	580 sq ft	*Range:*	320 miles

C/ns: 1, 2



The replica B & W made its first flight on May 25, 1966. (*Boeing Photo P-39993*)

MODEL 1A (B & W 1A) – To commemorate its 50th anniversary on July 15, 1966, Boeing built a full-scale replica of its first aeroplane, the B & W, to emphasize the great advances made in aircraft design over the half century. Rather than give the replica a new Boeing c/n in the jet airliner range, it was given c/n 1A.

While the outward appearance was authentic, many internal changes were made in the interest of production economy, structural integrity, safety afloat, and airworthiness. Principal changes were the use of welded steel tubing for the fuselage and tail, modernized flight controls and instrumentation, and a modern Lycoming GO-435 engine de-rated to 170 hp. In spite of a 500-pound increase in empty weight, the increased engine power and improved aerodynamics gave the replica the same performance as the original.

Boeing requested the registration number 1916B. This was not available, so 1916L was assigned and applied very inconspicuously to the fuselage beneath the horizontal stabilizer.

Although the aircraft was completed and initially flown as a pure

The replica B & W taking off from Lake Washington. (*Boeing Photo P-40005*)

Boeing Model 2, the C-4 seaplane, with small vertical radiators and parallel centre section structs. The apparent dark colouring is varnish applied over clear-doped fabric. (*Boeing Photo P-110*)

seaplane, bolt-on wheels were soon added to the floats to enable the replica to be demonstrated at air shows held on regular airports.

MODEL 2 (C-4) – The C-4 was so named because it was the third aeroplane design used and the fourth aeroplane owned by Boeing, including the Martin seaplane. It was the second Boeing design, even though the firm was still known as Pacific Aero Products at the time it was built, and carried Serial Number 3 because it was the third aeroplane built. It was an entirely original design and differed considerably from the B & W both in basic aerodynamic characteristics and general appearance. The wings had an unusual degree of stagger and dihedral angle compared to other aircraft of the period for the purpose of providing inherent stability. This was considered by the Boeing engineers as the most desirable characteristic for a training aeroplane. The tail surfaces differed from the B & W in that the horizontal stabilizer was deleted and a vertical fin added. The C-4 was dismantled after testing but was rebuilt and flown in August 1918. See Model 3 for specifications.

MODEL 3 (C-5, 6, 11) – Slightly revised versions of the Model 2 (C-4), the major outward difference being rearrangement of the centre section struts to join at the centre line of the upper wing. C-5 and C-6 were sold to the US Navy for evaluation as trainers after the United States entered WW-I and C-11, rebuilt from the C-4, was delivered to a private owner in July 1918.

TECHNICAL DATA - C-5

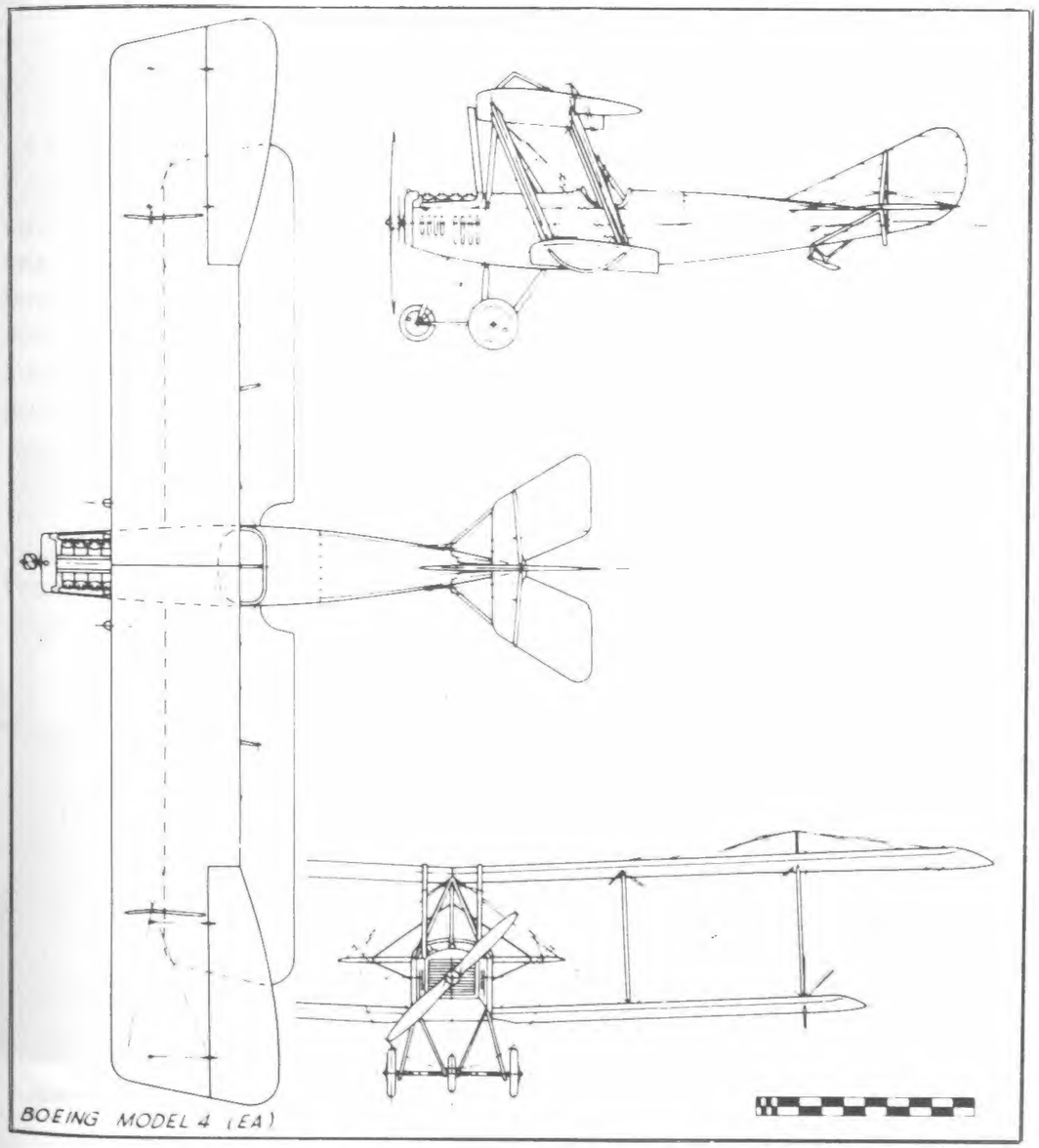
Type:	Trainer
Accommodation:	2 in tandem
Power plant:	Hall-Scott A-7A, 100 hp
Span:	43 ft 10 in
Length:	27 ft overall

Boeing Model 3, the C-5 seaplane tested by the US Navy with clear-doped finish and the new 1917 military tail striping. Compare larger radiators, modified centre section struts, and vertical tail size to Model 2. (*Courtesy Edgar Wischnowski*)

Height:	12 ft 7 in	*C/ns:*	6, 7, 8
Wing area:	495 sq ft	*Navy serial*	
Empty weight:	1,898 lb	*numbers:*	147, 148
Gross weight:	2,395 lb		(for 6 and 7)
Max speed:	72.7 mph		
Cruising speed:	65 mph		
Service ceiling:	6,500 ft		
Range:	200 miles		

Model 4, the EA landplane. The undercarriage was not a true tricycle; the extra wheel was to prevent nose-overs by student pilots. (*Photo by Herb Munter, courtesy Boeing*)

MODEL 4 (EA) – The two EAs were the first Boeing landplanes, and were essentially Model 3s with side-by-side seating and conventional wheel undercarriage supplemented by a third 'anti-nose-over' wheel. The power plant was a 100 hp Curtiss OXX-3 engine in place of the Hall-Scott. The designation EA is believed to be a continuation of the alphabetical series of model designations (Model 2 was C, Model 3 could have been D) combined with A-for-Army since they were designed for the US Army. Although the aircraft were delivered in January 1917, the purchase contract was not signed until April, after the United States had entered WW-I.

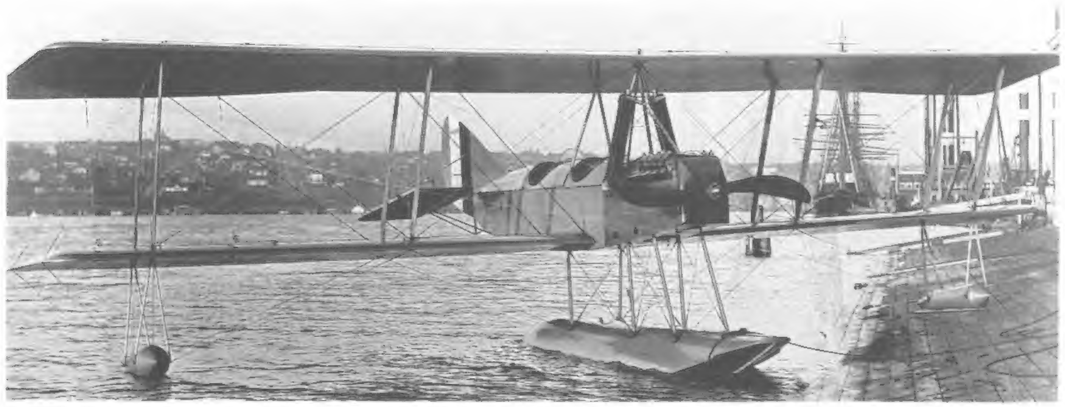


TECHNICAL DATA - EA

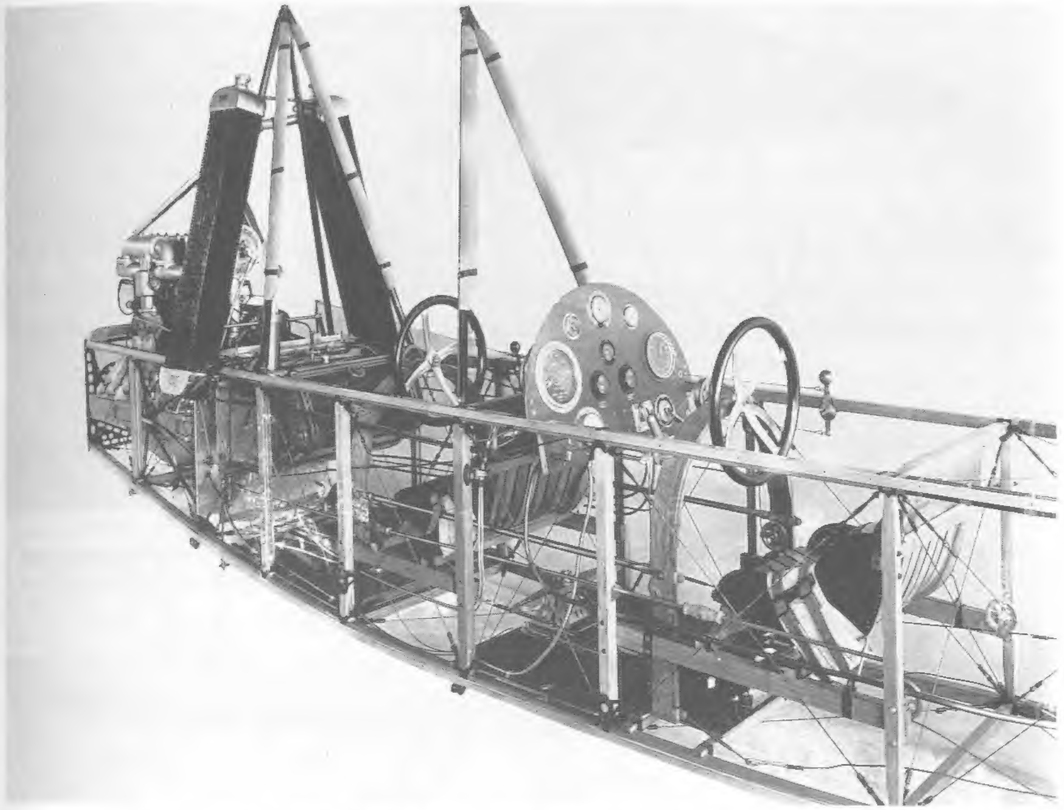
Type:	Trainer
Accommodation:	2 side-by-side
Power plant:	Curtiss OXX-5, 100 hp
Span:	48 ft 10 in
Length:	24 ft 10 in
Wing area:	479 sq ft
Empty weight:	1,598 lb
Gross weight:	2,185 lb
Max speed:	67 mph
Cruising speed:	60 mph
Climb:	438 ft/min
Service ceiling:	7,000 ft
Range:	280 miles
C/ns:	4, 5
Army serial numbers:	536, 537

MODEL 5 (C-650-700, C-1F, CL-4S) - Fifty Model 5s were ordered by the Navy as primary trainers following evaluation of the two Model 3s (C-5 and C-6) which can be considered the military prototypes. Since the production models were practically identical, Boeing retained the designation of Model C, supplementing it with the Navy-assigned serial number 650 to 699 for each individual aeroplane. The Navy ordered one additional aircraft (A-4347) for test with a single main float installation and a Curtiss OXX-6 engine. This was identified by Boeing as the C-1F (meaning Model C with one float). Before the C-1F was completed, the single float installation was tested on the rebuilt Model 2 (C-4), that became the C-11.

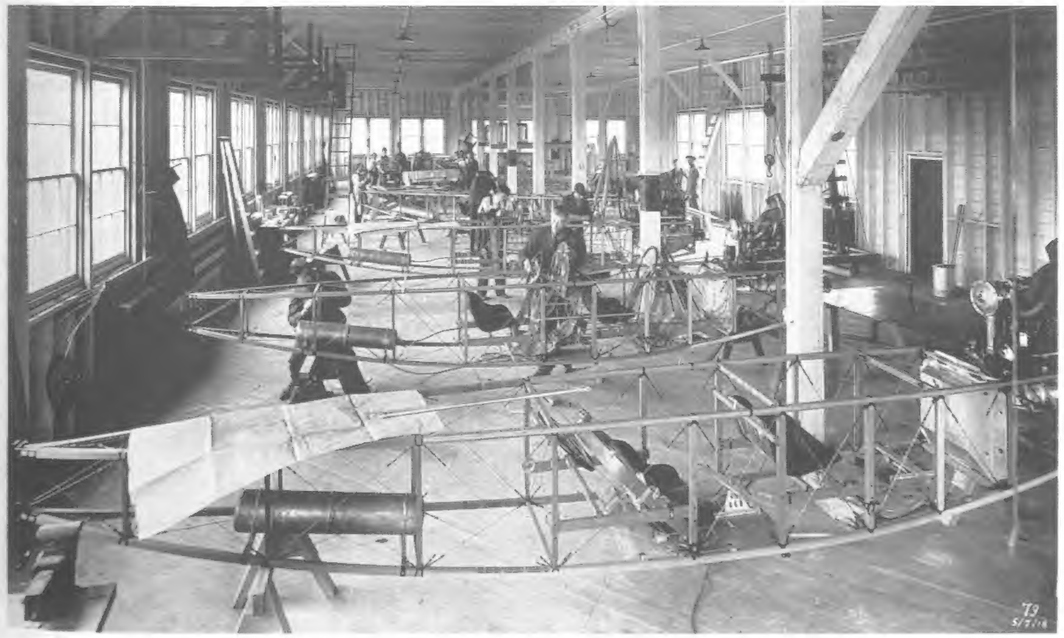
One additional Model C was built for William E Boeing, and since it followed the last Navy trainer, C-699, through the shop, it was logically called C-700. The C-700 was modified slightly in December 1918, and redesignated CL-4S, indicating a Model C with the new four-cylinder Hall-



The C-1F seaplane, a single-float version of the standard C-650-699 (Model 5) with Curtiss OXX-6 engine. Standard Navy colouring in 1918 was over-all stone grey. (*Boeing Photo P-138*)



Uncovered forward fuselage of a Boeing Model C Navy trainer, showing the rear-cockpit instrumentation and the heavy laminated wood yoke of the 'Dep' control system.



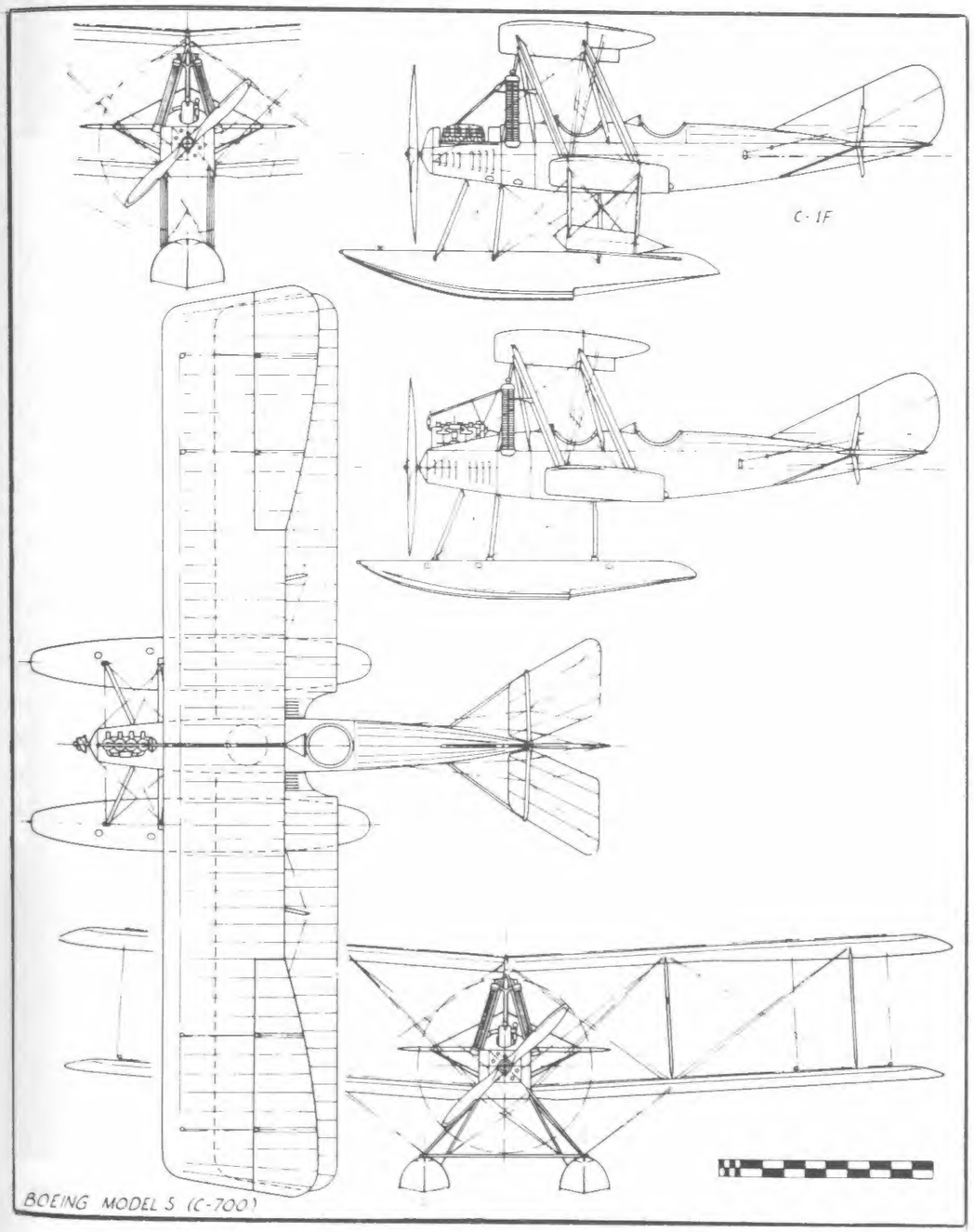
Assembly line of Model C fuselages. The cylindrical tanks in the rear held compressed air for the engine self-starters. (*Boeing Photo P-79*)

The C-700, a private machine built for William Boeing's use at the end of Navy C-650-699 production and duplicating the Navy trainers even to the use of military markings. Note reversed order of rudder stripes from 1917. (*Boeing Photo P-108*)

The C-700 modified to CL-4S by installation of improved Hall-Scott L-4 engine and reduction of aileron size to straighten trailing edge of wing. (*Boeing Photo P-143*)

A war-surplus Boeing C converted to a landplane by a private owner. The unreliable 100 hp Hall-Scott A-7A engine was replaced by a dependable 150 hp Wright-Hispano. Note the two-seat front cockpit. (*Bowers Collection*)

Scott L-4 engine. This aeroplane was used by William Boeing and Edward Hubbard on March 3, 1919, to make a demonstration international air mail flight from Vancouver to Seattle in connection with a Canadian exposition. This flight inspired the later inauguration of the Seattle—Victoria Contract International Air Mail route (*see* page 49), where transpacific mail was delivered to and picked up from ships a day out of Seattle. Since it was operating in Canada at a time when Canadian aircraft had to carry registrations but US aircraft did not, it was registered as G-CADR (G for Great Britain, CA for Canada) for the initial part of its mail service. The



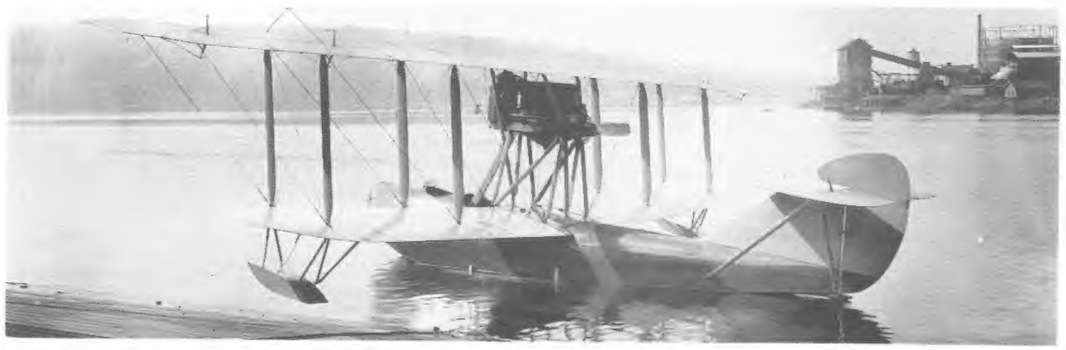
G-prefix was soon changed to the assigned N for the United States to show its true ownership.

The Navy declared all the Model Cs surplus after WW-I, taking full-page ads in the aviation magazines to advertise them and quote the original price of $10,250 each. About the first thing the private owners did was to replace the highly unreliable Hall-Scott engines with either 90 hp Curtiss OX-5s or 150 hp Wright-Hispano surplus engines. Several Cs were still flying when US registration became mandatory in January 1927, and at least two were painted in German WW-I markings and crashed for the film 'Dawn Patrol' in 1931.

TECHNICAL DATA - C-650/C-700

Accommodation:	2 in tandem
Power plant:	Hall-Scott A-7A, 100 hp
Span:	43 ft 10 in
Length:	27 ft overall
Height:	12 ft 7 in
Wing area:	495 sq ft
Empty weight:	1,898 lb
Gross weight:	2,395 lb
Max speed:	72.7 mph
Cruising speed:	65 mph
Service ceiling:	6,500 ft
Range:	200 miles
C/ns:	9/60
Navy serial numbers:	650/699 for c/n 10/59, 4347 for c/n 9

MODEL 6 (B-1) - The B-1, which first flew on December 27, 1919, was a conventional pusher flying-boat with laminated veneer hull. The design drew heavily on Boeing's experience with the wartime Curtiss HS-2Ls (see Chapter 2) but the size was greatly reduced to make the machine easier to operate and maintain. Since this was the first commercial design of the Boeing Airplane Company, it was given the logical designation of B-1 for sales purposes. The fact that it did not sell was no reflection on the design.



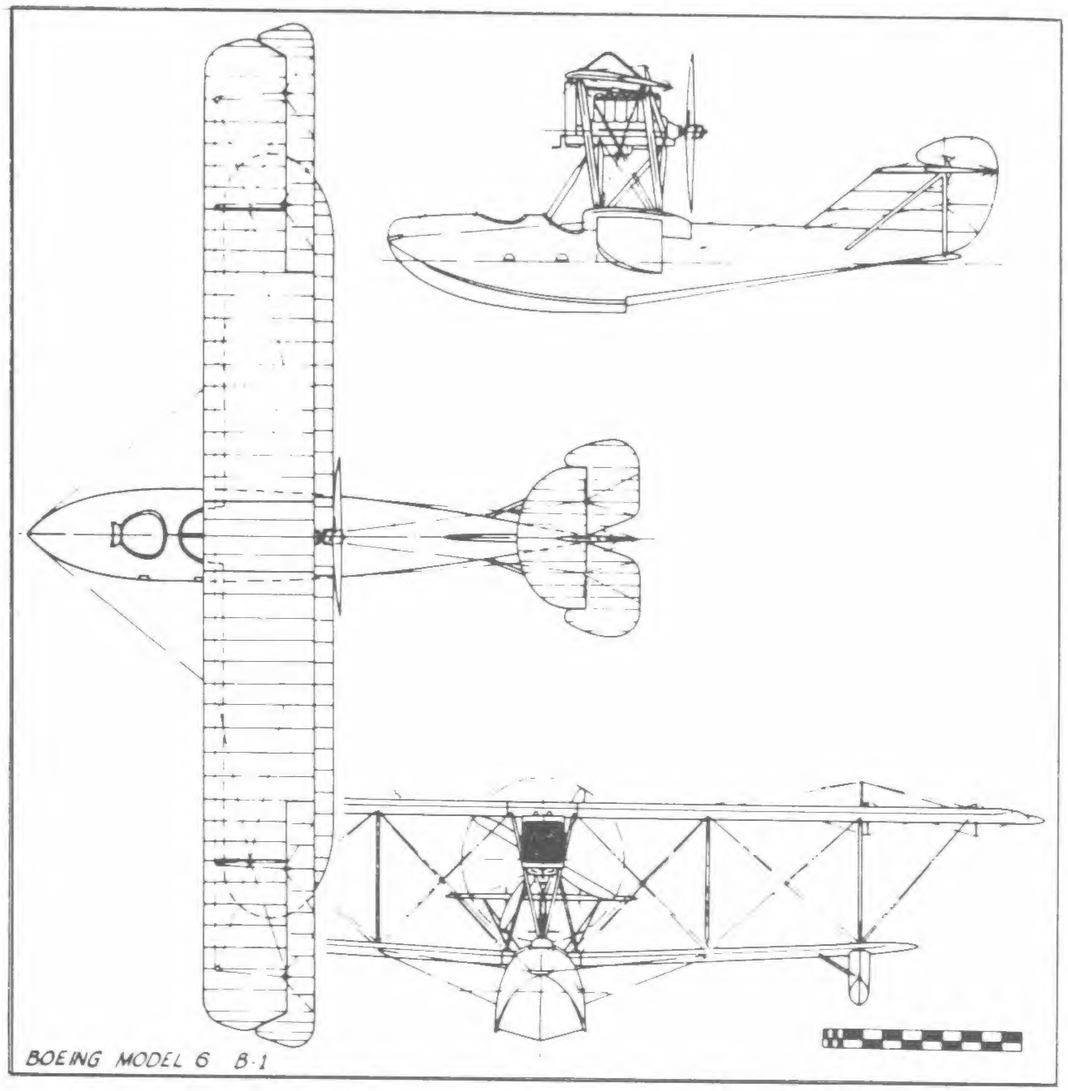
Original form of the B-1 (Model 6) flying-boat with six-cylinder Hall-Scott L-6 engine and small strut-mounted wingtip floats. (*Boeing Photo P-237*)

The B-1 operated into Canada from 1920 to 1923 with the letter N to identify United States ownership but with letters CA indicating Canadian registration. Note that the four-blade propeller is built up from two two-blade units, not built in one piece as those on page 56. (*Photo courtesy Arthur E Price*)

Cheap war-surplus military models flooded the market and costly new models could not compete.

The single B-1 was sold to Edward Hubbard in 1920 and was used continuously for eight years on his Seattle—Victoria air mail route. The original power plant was a 200 hp Hall-Scott L-6, so designated because it was a 6-cylinder version of the famous wartime Liberty, but this was replaced by the standard 400 hp 12-cylinder Liberty. Because of the Canadian registration requirement, the B-1 was registered as G-CADS for operation in Canada. This was replaced by N-CADS and later by N-ABNA when an unofficial US registration scheme was set up by the National Board of Fire Underwriters in 1923 (N had been assigned as the identifying letter

Final form of B-1 with enlarged wingtip floats and Liberty engine, seen hopping passengers at a 1924 Boeing company picnic. Registration N-ABNA was used from 1923 to 1927. (*Photo by Arthur E Price*)



for US aircraft at the International Convention of 1919, but the US did not adopt the standardized scheme used by the other powers. When official US registration was adopted in 1927, the B-1 became 4985 and then 1974, which was later modified to NC-1974. Although not qualifying for either an Approved Type Certificate or a Memo Approval, the B-1 was licensed for commercial operation after 1927 as a Category-III aeroplane.

The B-1 remained in use throughout the 1920s. It was eventually obtained by the Seattle Historical Society and set up as an outdoor display on Boeing Field in 1934. Weather and small boys took their toll, and the B-1 was dismantled, crated, and stored by Boeing until after WW-II, when it was rebuilt and put on permanent indoor display in the Seattle Museum of History and Industry in 1954.

Note: Two production aeroplane models, the B-1D and B-1E were built under this model number in 1928–29, but are described in Chapter 4 because of their much later design.

TECHNICAL DATA - B-1

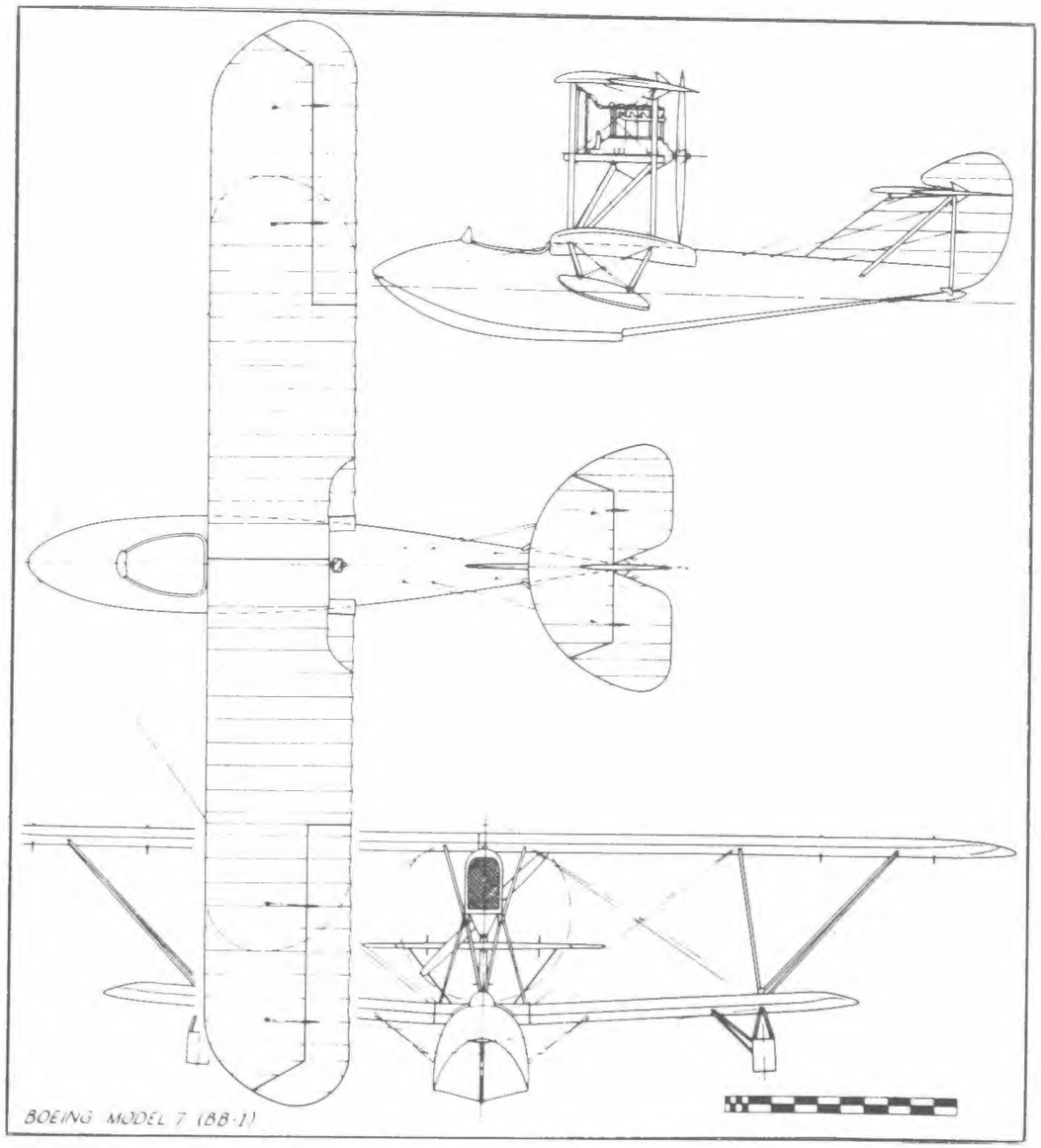
Type:	Mail/passenger flying-boat
Accommodation:	1 pilot in front cockpit, 2 passengers in rear cockpit
Power plant:	Hall-Scott L-6, 200 hp; Liberty, 400 hp
Span:	50 ft 3 in
Length:	31 ft 3 in
Height:	13 ft 4 in
Wing area:	492 sq ft
Empty weight:	2,400 lb (L-6)
Gross weight:	3,850 lb (L-6)
Max speed:	90 mph (L-6)
Cruising speed:	80 mph (L-6)
Service ceiling:	13,300 ft
Range:	400 miles (L-6)
C/n:	86
Registrations:	G-CADS, N-CADS, N-ABNA, 4985, 1974

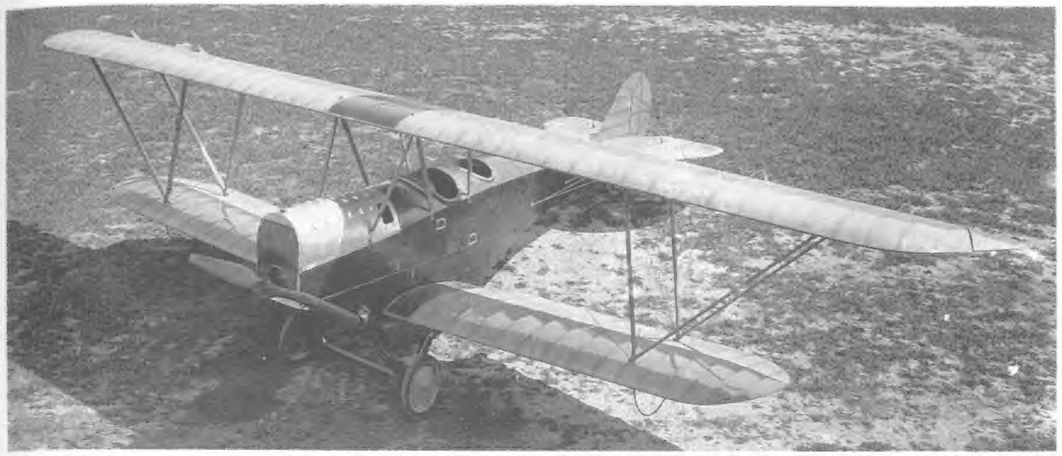
MODEL 7 (BB-1) – The BB-1 was a sporting and commercial flying-boat slightly smaller than the B-1 but following its general proportions and construction. The three occupants were in a single cockpit, the pilot in a single seat forward and the two passengers side-by-side behind him. The wing strut arrangement was a double Vee uncommon in American practice. The BB-1 first flew on January 7, 1920, and was sold to the Aircraft Manufacturing Company of Vancouver, Canada.

TECHNICAL DATA - BB-1

Accommodation:	1 pilot, 2 passengers
Power plant:	Hall-Scott L-4, 130 hp
Span:	45 ft 6 in
Length:	27 ft 8 in
Height:	11 ft 8 in
Wing area:	403 sq ft
Empty weight:	2,028 lb
Gross weight:	2,699 lb
Max speed:	84 mph
Cruising speed:	75 mph
Service ceiling:	10,000
Range:	500 miles
C/n:	87

The BB-1 (Model 7), a smaller and lighter refinement of the B-1. (*Boeing Photo P-252*)





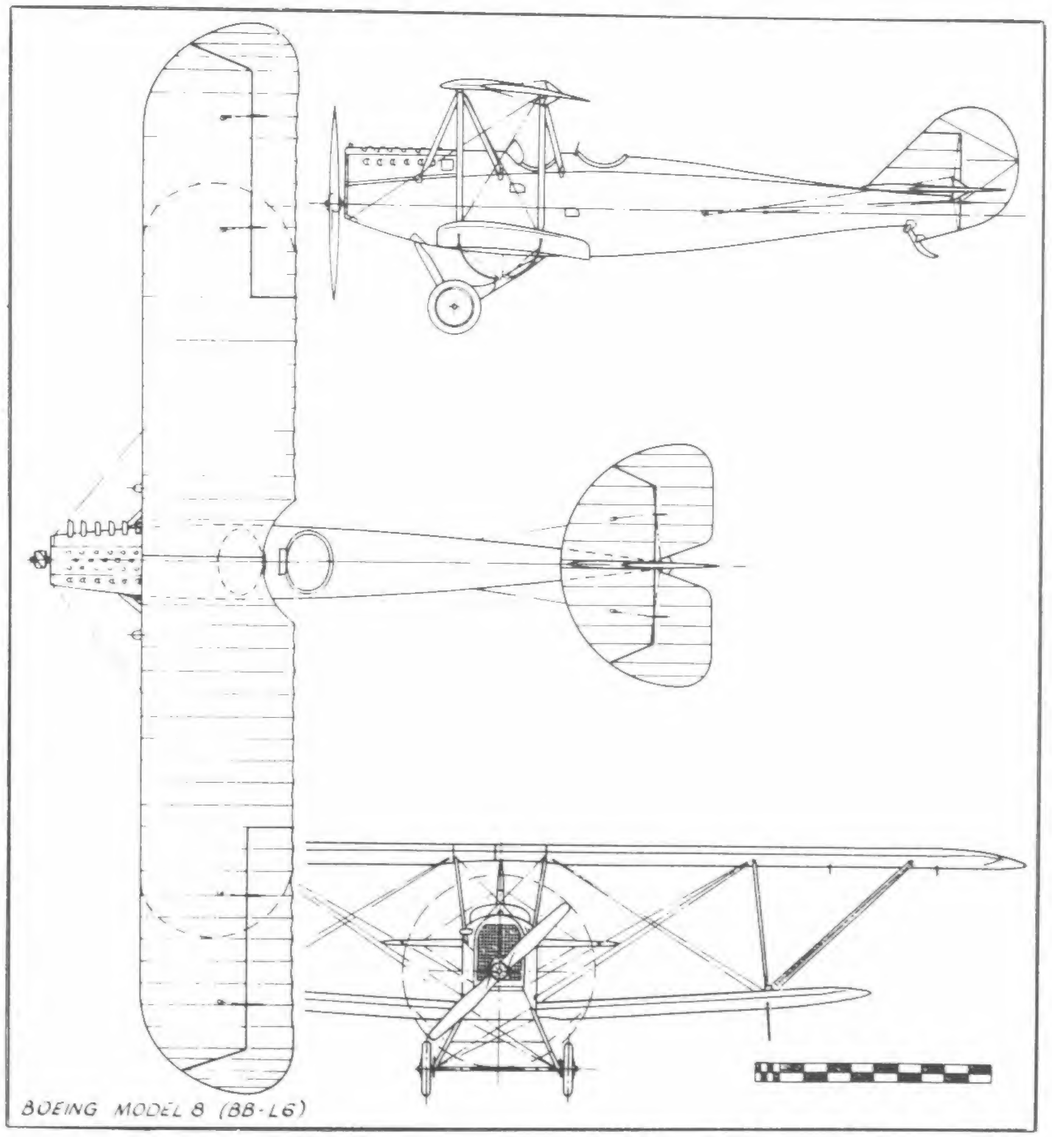
The BB-L6 (Model 8), showing the wide two-seat front cockpit. The aeroplane displays natural wood and fabric finish since it was not customary to paint civil aeroplanes in the early post-WW-I days. (*Boeing Photo P-271*)

MODEL 8 (BB-L6) – The BB-L6 was built to the order of Herb Munter, Boeing's first test pilot, and the fuselage design was inspired by the wartime Italian Ansaldo Ballila, one of which was in Seattle at the time. The fuselage cross-section changed from the traditional four longeron rectangle in the engine-cockpit area to a three longeron inverted triangle aft of the rear cockpit. The entire fuselage was covered with mahogany plywood. The wing configuration and power plant were similar to the BB-1 flying-boat, and the L6 in the designation identified the Hall-Scott L-6 engine. Two passengers were carried side-by-side in the front cockpit and the pilot was in the single rear cockpit, a configuration that was to remain standard for all subsequent American three-seat open-cockpit biplanes. The BB-L6, which first flew on May 24, 1920, is credited with making the first flight over Mt Rainier, a 14,400 ft peak that was to become virtually a Boeing trademark when used as a background for photographs of later Boeing aeroplanes. The single BB-L6 was destroyed in a hangar fire at Kent, Washington, in 1923.

This view of the BB-L6 shows to advantage the centre-section and interplane struts. (*Boeing Photo P-261*)

TECHNICAL DATA - BB-L6

Type:	Passenger
Accommodation:	1 pilot, 2 passengers
Power plant:	Hall-Scott L-6, 200 hp
Span:	44 ft 9 in
Length:	29 ft 3 in
Height:	10 ft 10 in
Wing area:	465 sq ft
Empty weight:	1,652 lb
Gross weight:	2,632 lb
Max speed:	100 mph
Cruising speed:	90 mph
Service ceiling:	15,000 ft
Range:	450 miles
C/n:	199



Chapter 2

FURNITURE - AND OTHER PEOPLE'S AEROPLANES

Because of the rapid advances made in aeroplane design and performance during WW-I, a rosy future was predicted for commercial aviation as soon as the end of hostilities could free the factories form the demands of purely military production; thousands of war-trained pilots would form the nucleus of a vast pool of private owners and would be the logical ones to operate the airmail and passenger routes that were expected to spring up.

Actually, the picture turned out to be quite different. While most manufacturers rushed to design new aeroplanes for purely commercial use, they could not sell them because of surplus military stocks which were dumped on the market. Surplus aeroplanes, still in their original crates and suitable for joyriding and training, sold for a few hundred dollars and completely killed the market for new production models that were definitely more efficient but between 10 and 15 times more costly. Not until the war-surplus stocks began to wear out, some seven years after the armistice, was new production able to gain a significant place in commercial aviation.

The military aircraft situation was only a little better. While few American-built aircraft saw action in France, industry had finally entered into large-scale production and thousands of trainers and two-seat observation aircraft were on hand at the time of the armistice. Even after the majority had been disposed of as surplus, there were enough to fulfil normal needs for years and there was little demand for replacements.

While the US Army Air Service was deficient in some basic aircraft types at the end of the war, little was done toward filling the gaps immediately and the aviation industry faced a bleak period in which it could sell neither commercial nor military aircraft. Some of the war-born companies simply disbanded while others sought to preserve their organizations by turning out non-military products.

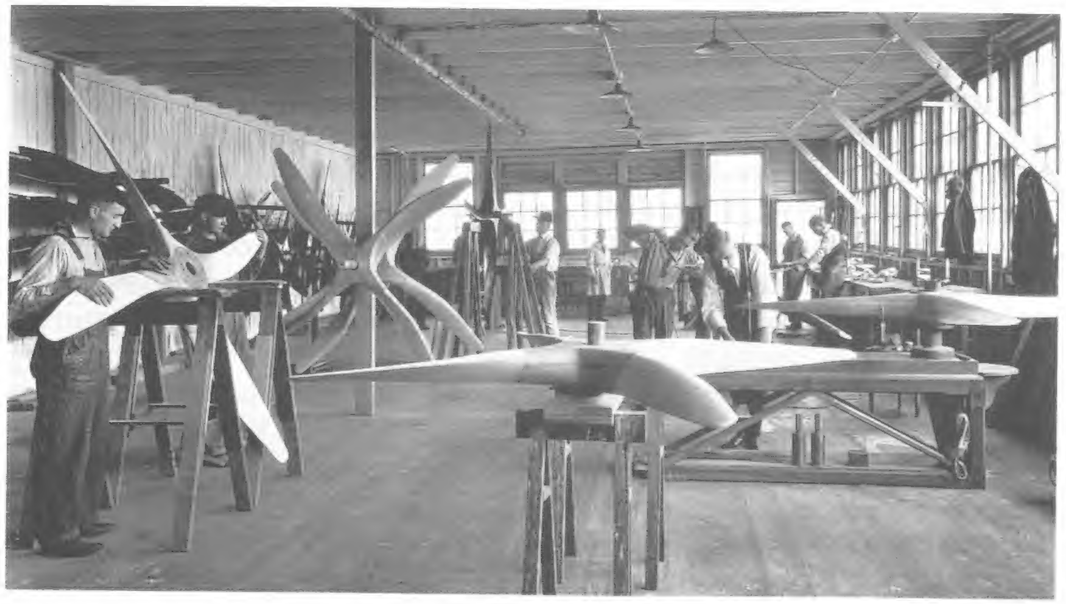
Boeing, an organization of skilled woodworkers in a major lumber-producing area, turned naturally to products that could be produced by the same personnel, tools, and raw material. These included bedroom furniture, canoes, and unique high-powered sea sleds manufactured under the Hickman Patents held by the Sea Sled Company of Boston, Mass. Some of these sleds were large enough to carry an aeroplane, and experiments were conducted in launching landplanes from them.

By 1920 the military picture brightened a bit and orders were placed with

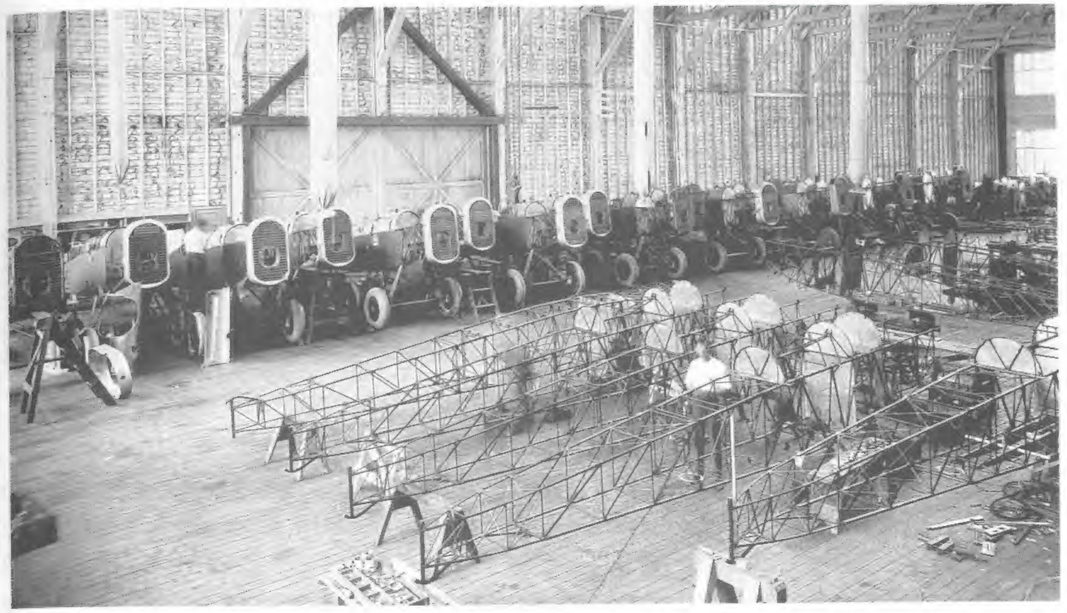
The Hickman Sea Sled, which Boeing manufactured in addition to furniture and other non-aircraft products during the decline in aeroplane manufacturing that followed WW-I (*Bowers Collection*)

the aircraft industry for several hundred new aeroplanes under the prevailing procurement system. At this time, when the Army Air Service bought a new prototype aeroplane from a manufacturer it also bought the design rights. If testing showed the aeroplane to be desirable as a production type, bids were invited from the entire industry rather than from just the original designer. Under this system, Boeing was low bidder on a contract for 200 Thomas-Morse MB-3A single-seat fighters while the original designers got an order for only 50. Boeing already had experience in building other people's aeroplanes, having produced Curtiss-designed HS-2Ls for the Navy in 1918.

Another Army practice until about 1924 was for the Air Service to design aircraft of its own at McCook Field, Dayton, Ohio, sometimes even building



Boeing designed and built its own propellers in the early 1920s. These four-bladers are for the MB-3A pursuit aircraft. (*Boeing Photo P-203-B*)

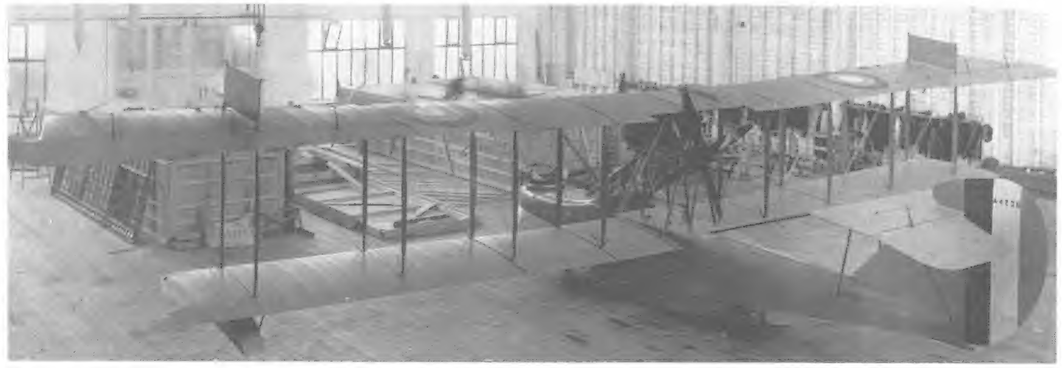


Factory interior on July 21, 1924, showing large-scale production of steel tube fuselages for use on rebuilt WW-I De Havilland 4 observation aircraft. (*Boeing Photo P-734-B*)

a prototype, and then asking for bids from industry for actual production. The Navy followed a similar procedure well into the 1930s by designing aircraft and sometimes building prototypes at the Naval Aircraft Factory, Philadelphia. The production of desirable models was contracted to industry while at other times only general designs were worked up, later being turned over to industry for completion of detail design and construction of a prototype.

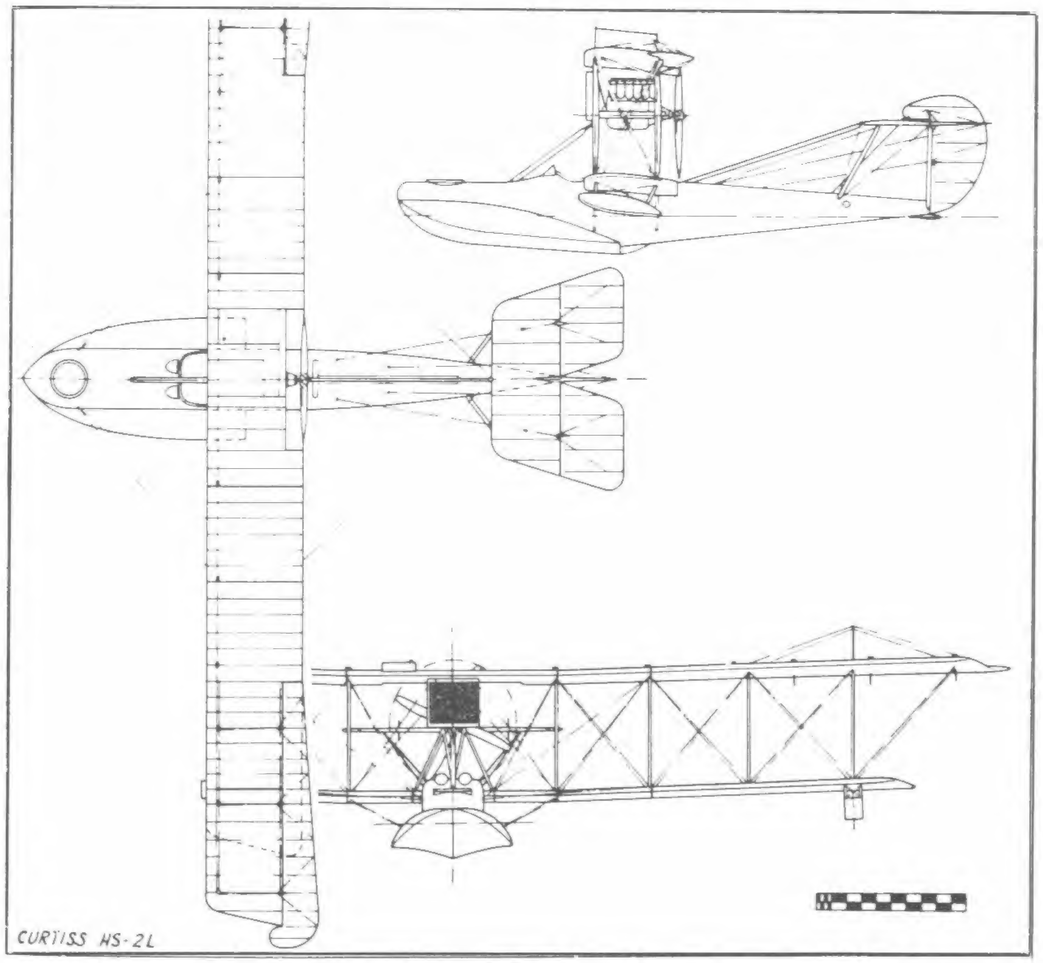
A third source of government business in the early postwar years was the extensive rebuilding of the wartime de Havilland DH-4 observation type. Boeing obtained a large share of this work, which, combined with the MB-3 order and the development of the Army GA-1 and GA-2 attack designs, enabled it to abandon furniture and boat building and return to the full-time production of aeroplanes.

Even after it had become well re-established in the manufacture of its own aeroplane designs as well as government modernization programmes and production of government-designed aeroplanes, Boeing installed twin wooden floats on the four Douglas World Cruisers of the Army's 'Around the World' flight which originated in Seattle on April 4, 1924, and was completed by two of the original aircraft returning to Seattle on September 28. Boeing also took on aircraft maintenance and repair work, a practice that extended well into the 1930s. Probably the best-known non-Boeing aeroplane worked on was the former Wilkins' Arctic Expedition *Detroiter*, a Fokker trimotor monoplane shipped to Seattle from Alaska in 1927 and reassembled by Boeing for Charles Kingsford Smith, who renamed it *Southern Cross* prior to attempts on the world's endurance record and the first US to Australia transpacific flight in 1928.



Curtiss HS-2L flying-boat, the first of several non-Boeing designs that the company was to build between 1918 and 1927. (*Boeing Photo*)

CURTISS HS-2L (No Boeing Model Number) – In keeping with the policy of having several manufacturers build certain aircraft which were needed in quantity during WW-I, the Navy requested Boeing to build 50 Curtiss HS-2L single-engine patrol flying-boats. Construction was entirely conventional for the period, and fitted in well with Boeing seaplane experience, since the hulls were built up of crossed strips of wood veneer over wooden formers in much the same manner as used on the Boeing-



designed floats of the Model Cs. Construction was sufficiently under way at the time of the armistice to permit completion of the first 25 aeroplanes in spite of the large postwar contract cancellations. The Boeing-built HS-2Ls differed from those built by Curtiss, Standard, Lockheed, Gallaudet, and L.W.F. in not having ailerons on the lower wing. This model provided Boeing with the flying-boat experience that resulted in the B-1 and BB-1 boats of 1919–20.

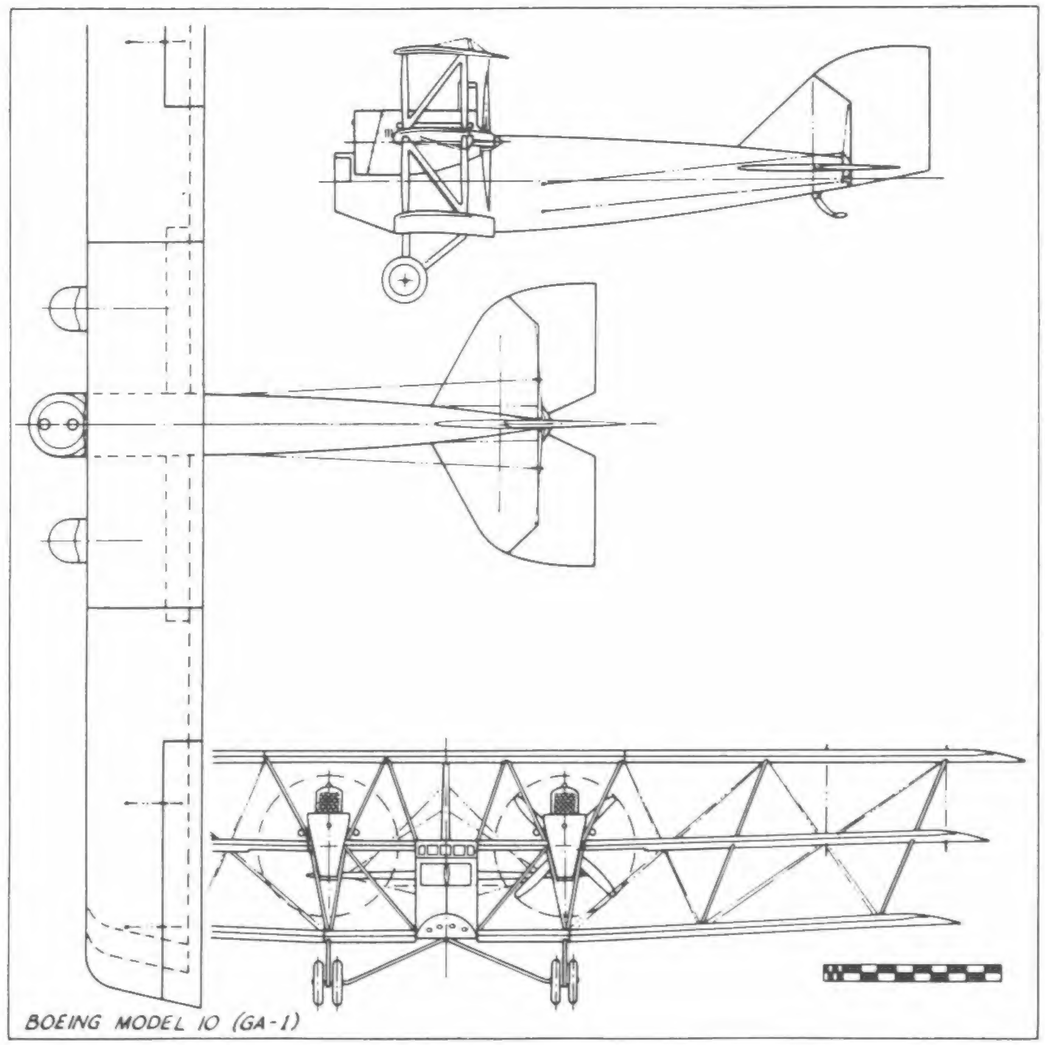
TECHNICAL DATA – HS-2L

Type:	Patrol flying-boat
Accommodation:	2 pilots, 1 bombardier/gunner
Power plant:	Low-compression Liberty, 360 hp
Span:	74 ft 1 in
Length:	39 ft
Height:	14 ft 7 in
Wing area:	803 sq ft
Empty weight:	4,359 lb
Gross weight:	6,432 lb
Max speed:	85 mph
Climb:	1,800 ft in 10 min
Range:	575 miles
Armament:	One Lewis MG, two 230 lb bombs
C/ns:	61/85
Navy serial numbers:	A-4231/4254

MODEL 10 (GA-1, GA-2) – The Boeing designation of Model 10 was assigned to two completely dissimilar attack aeroplanes designed by the Engineering Division of the US Army Air Service at McCook Field, Ohio. This was just at the time the Army was beginning to standardize designations for new aeroplane designs, and the designations stood for Ground Attack Designs No. 1 and 2 in sequence.

Boeing Model 10, the GA-1 attack triplane, production version of the GA-X prototype designed and built by the Air Service Engineering Division, under the insignia of the 90th Attack Squadron. (*Courtesy Museum of Flight*)

• GA-1 – The Army-built prototype was identified as GA-X for Ground Attack Experimental. The pilots who flew it had their own designation for it – Guns, Armor, and X – the Unknown Quantity, as in algebra. This was an armoured twin-engine pusher triplane built at McCook Field. Boeing was the successful bidder for the 20 production models to be built by the industry. Except for the extensive use of armour plate as an essential part of the basic structure in the crew and power plant areas, construction was the standard wood and wire with fabric and plywood covering. Rigging of the wings was somewhat simplified by the use of one-piece N-struts that eliminated the usual incidence wires. Triplanes were not uncommon during WW-I, and while the ten GA-1s (the order was halved after it was placed) were the world's last production three-wingers, they were not distinguished by this now rare characteristic. Their most unique feature was the armament-power plant arrangement, where a gunner rode in the front of each pusher engine nacelle. All fired their guns through slits in the armour, sighting through peep-holes protected by movable shutters. Even the pilot had shutters for straight-ahead vision. Additional armament was fixed to



fire downward through the floor as the GA-1 passed over the target.

The GA-1s, which first flew in May 1921, were grossly overweight because of their armour, crew visibility was poor, and there were serious aerodynamic and engine cooling problems. In spite of these deficiencies, all 10 were accepted by the Army and delivered by rail to Kelly Field, Texas, where their poor characteristics endowed them with a unique disciplinary function. All a commander had to do to keep exuberant young pilots on their best behaviour was to threaten to assign them to the triplanes.

TECHNICAL DATA - GA-1

Type:	Ground attack
Accommodation:	1 pilot, 2 gunners in three cockpits
Power plant:	2 Liberty 12A, 435 hp
Span:	65 ft 6 in
Length:	33 ft 7 in
Height:	14 ft 3 in
Wing area:	1,016 sq ft
Empty weight:	7,834 lb
Gross weight:	10,426 lb
Max speed:	105 mph
Cruising speed:	95 mph
Climb:	600 ft/min
Service ceiling:	9,600 ft
Range:	350 miles
Armament:	Eight ·30 cal MG, one 37 mm cannon
C/ns:	200/209
Army serial numbers:	64146/64155

• GA-2 – This was a large single-engine armoured biplane designed at McCook Field and powered by an untried Army-designed three-bank engine of 700 hp. Boeing was given a contract to build two prototypes. Since the new engine was not available at the time, a wooden mockup was delivered. Boeing found it necessary to do a considerable amount of detail redesign, and made more extensive changes in the second aeroplane as the result of experience with the first. Construction, including the use of armour plate, was generally similar to the GA-1. Both GA-2s were delivered to McCook Field by rail for testing and were not flown at Seattle.

TECHNICAL DATA - GA-2

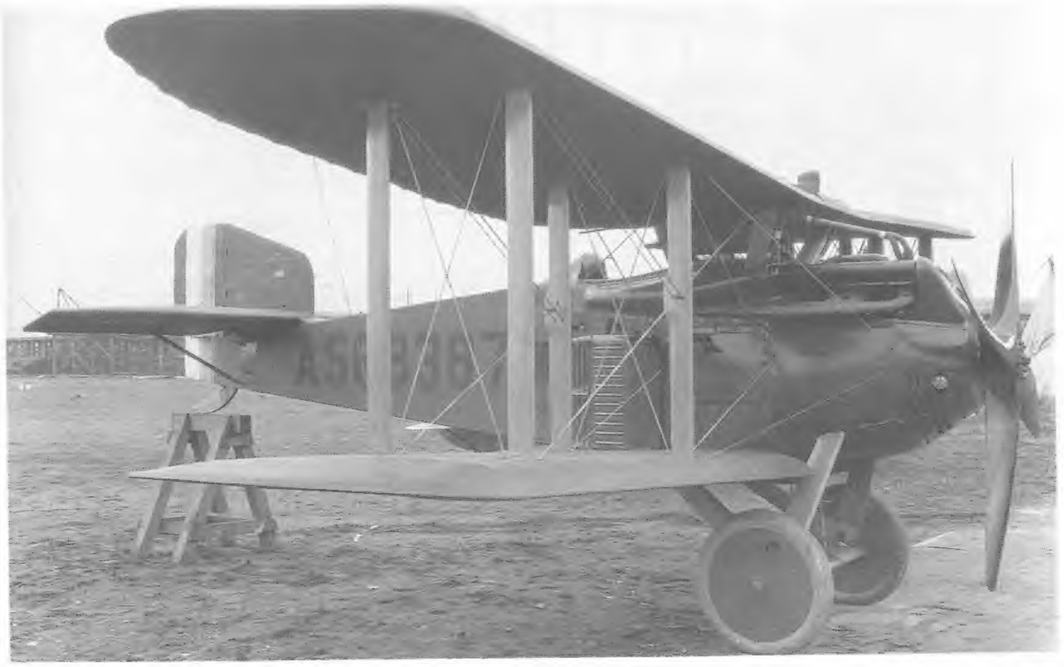
Type:	Ground attack
Accommodation:	1 pilot, 2 gunners
Power plant:	Engineering Divison W-18, 750 hp
Span:	54 ft 0 in
Length:	36 ft 9 in
Height:	12 ft 0 in

GA-2, built by Boeing to Air Service drawings, was also designated as Boeing Model 10. Only two were built. (*USAF McCook Field Photo*)

Wing area:	851 sq ft
Empty weight:	6,469 lb
Gross weight:	8,691 lb
Max speed:	113 mph
Cruising speed:	100 mph
Climb:	720 ft/min
Service ceiling:	12,000 ft
Range:	200 miles
Armament:	Six ·30 cal MG, one 37 mm cannon
C/ns:	410,411
Army serial numbers:	64235, 64236

THOMAS-MORSE MB-3A (No Boeing Model Number) – Under the Army Air Service procurement system in effect right after WW-I, Boeing

The first MB-3A, built after Boeing won industry-wide bidding for manufacture of 200 improved versions of WW-I Thomas-Morse pursuit design. (*Boeing Photo*)



MB-3A with new redesigned tail surfaces as installed on the last 50 machines. Colouring of Army combat aircraft from 1918 to 1927 was khaki-brown (olive drab) all over. (*Boeing Photo P-272-B*)

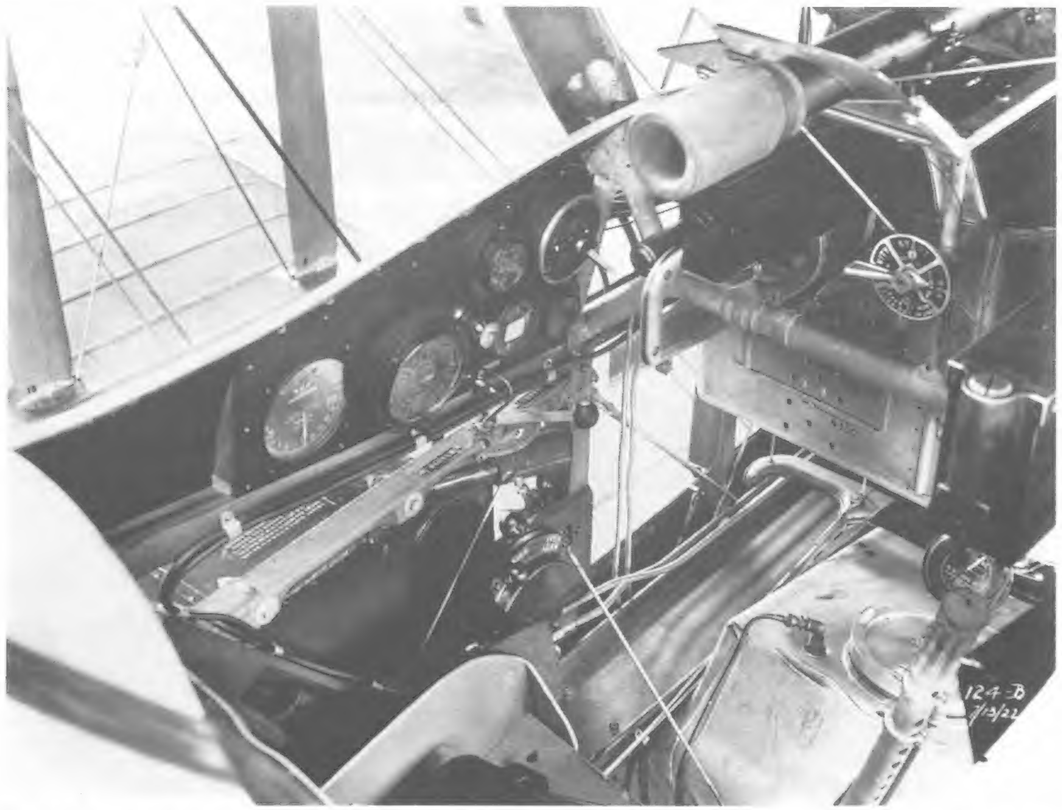
was the low bidder on a production aircraft for 200 MB-3 single-seat fighters designed late in 1918 by Thomas-Morse. The originating firm had received an order for 50 of its own MB-3 model while Boeing got the larger order for improved MB-3As with its low bid of $1,448,000.

The MB-3A was a conventional wood and wire fabric-covered biplane powered with the 300 hp Wright Model H engine, an Americanized French Hispano-Suiza. General structural and aerodynamic configuration was heavily influenced by the French Spad fighter of 1916–18. Construction

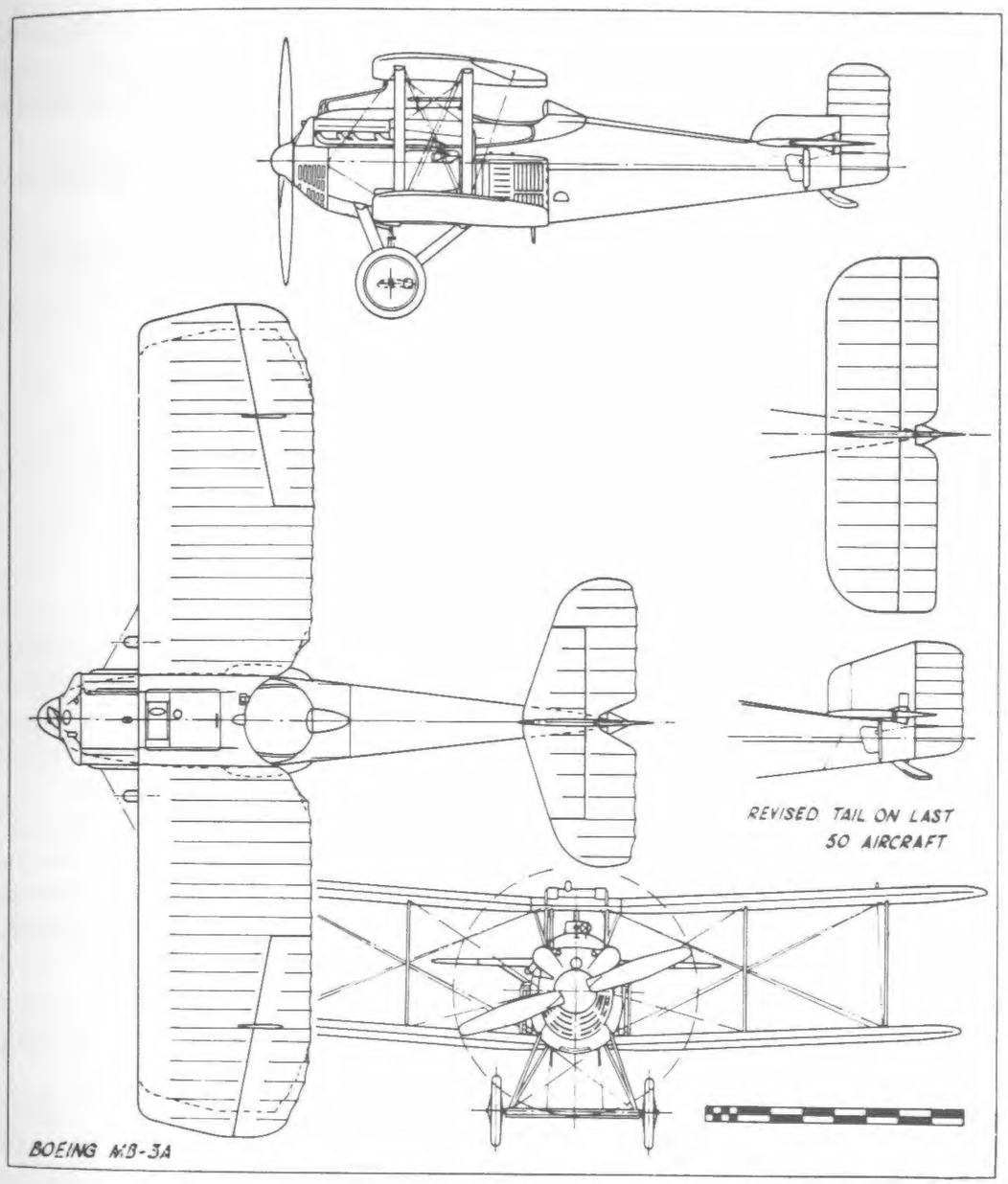
Condemned Army MB-3A made available to the producers of the 1927 cinema epic 'Wings', who used it to portray a fallen German Albatros D-III pursuit of WW-I (*Courtesy Fred G Freeman*)

Women employees stitching the upper wing fabric of an MB-3A, circa 1922. (*Boeing Photo 102-B*)

began early in 1921 and the final delivery was made on December 27, 1922. Some were fitted with two-blade propellers and others with four-blade, but the last 50 aeroplanes were fitted with entirely new tail surfaces of Army design. One model was built with special wings using four ailerons. The



The MB-3A did not have a conventional instrument panel. Instead, the standard instruments were installed on the sides of the cockpit. (*Boeing Photo 124-B*)



Army serial numbers for the MB-3As were the 68000 range while the MB-3 prototypes were 40092 to 40095 and the 50 MB-3s were 63331 to 63380. The Thomas-Morse models had the radiator in the centre section of the upper wing, but side radiators proved more efficient and the Boeing-built MB-3As were fitted with side radiators built by Thomas-Morse.

After a period of service as first-line fighters, many of the MB-3As were rebuilt by Fairfield Air Intermediate Depot (FAID) and sent to Kelly Field, Texas, where they were used as advanced trainers as late as 1927. Several, destined for the junk pile, were used as German fighters for crash scenes in the air-war film 'Wings', most of the flying sequences being taken near Kelly Field with Army co-operation.

TECHNICAL DATA - MB-3A

Type:	Fighter
Accommodation:	1 pilot
Power plant:	Wright H-3, 320 hp
Span:	26 ft 0 in
Length:	20 ft
Height:	7 ft 8 in
Wing area:	228 sq ft
Empty weight:	1,716 lb
Gross weight:	2,539 lb
Max speed:	140 mph
Cruising speed:	125 mph
Climb:	1,350 ft/min
Service ceiling:	19,500 ft
Armament:	Two ·30 cal MG
C/ns:	210/409
Army serial numbers:	68237/68436

MODEL 16 (de Havilland 4 Series, O2B-1) – In the early postwar years, the Army Air Service initiated a modernization programme for the original production models of the Liberty Plane, the British-designed de Havilland 4 of 1916 which had been put into large-scale production in the United States in 1918 after being redesigned to take the Liberty engine and conform to American production standards. The modernization job was turned over to the aircraft industry, and early models were rebuilt to the later de Havilland 4B standard. Later, after the Army had studied German designs taken to the United States after the armistice, it was greatly impressed by the strength and maintenance efficiency of the welded steel tube fuselage of the Fokker D.VII. As a result, another DH-4 modernization programme was initiated, this time to incorporate steel tube

The first De Havilland 4M-1, a rebuilt wartime DH-4B using the Boeing-developed arc welding process for an entirely new steel tube fuselage. (*Boeing Photo P-469-B*)

fuselages in rebuilt models to be known as DH-4M. Altogether, Boeing rebuilt 354 DH-4s from 1920 to 1925. Since weights and performance were similar for all versions, a single technical listing has been made for all.

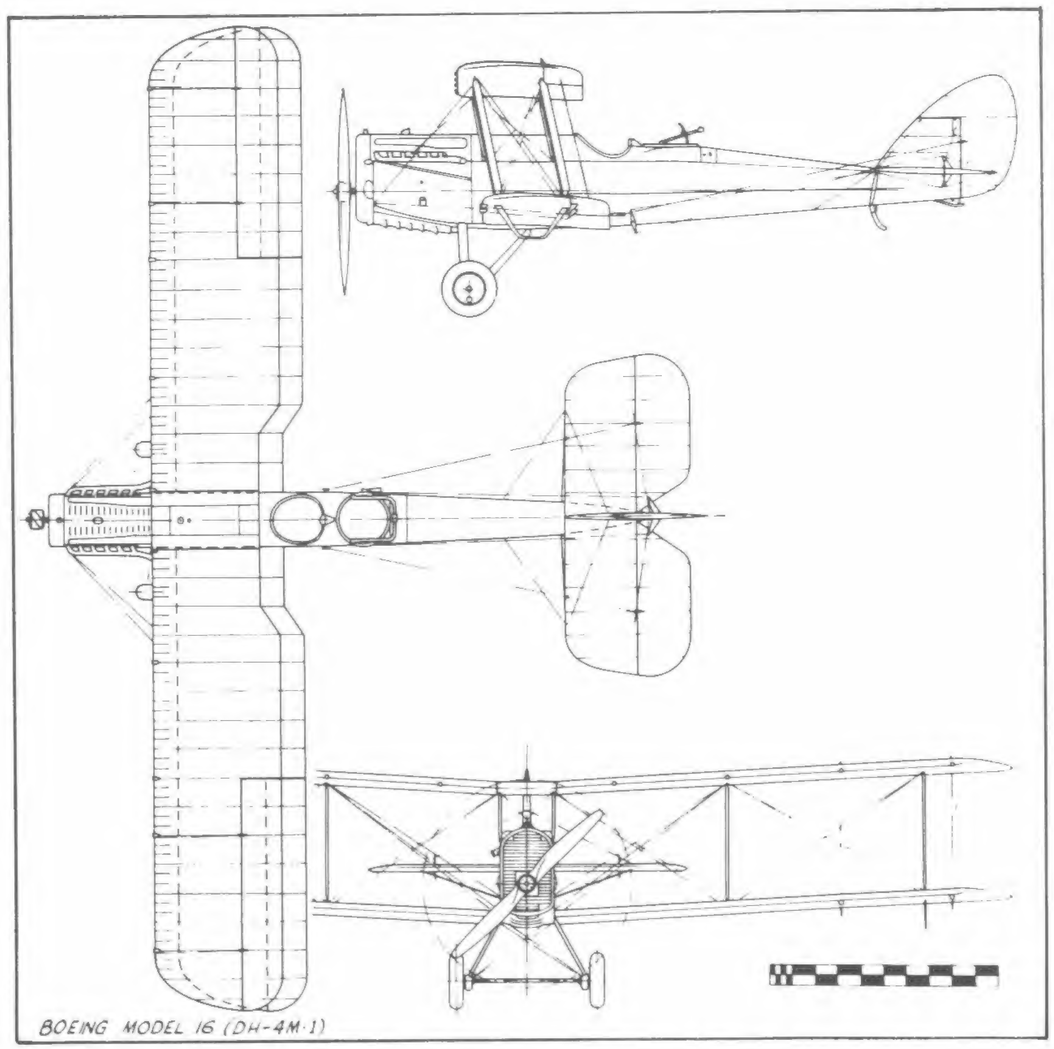
TECHNICAL DATA - DH-4

Type:	Observation/bomber/trainer
Accommodation:	2 in tandem
Power plant:	Liberty
Span:	42 ft 5 in
Length:	29 ft 11 in
Height:	9 ft 8 in
Wing area:	440 sq ft
Empty weight:	2,939 lb
Gross weight:	4,595 lb
Max speed:	118 mph
Cruising speed:	104 mph
Climb:	760 ft/min
Service ceiling:	12,800 ft
Range:	330 miles
Armament:	Two fixed, two flexible ·30 cal MG, one 400 lb bomb

Model	*C/ns*	*Army serial numbers*
DH-4B	88/198 (111)	63461/63507 63936 63761/63823
	412/461 (50)	22-1000/22-1049 (Rebuilt from above)
XDH-4M-1	515/517 (3)	68590/68592
DH-4M-1	462/511 (50) 515/517 (3) 519/618 (100)	Random original numbers (see Table, Appendix V)
O2B-1 (Navy)	619/648 (30)	A-6898/6927 (6924/6927 to O2B-2)
DH-4 Mail	652	Civil Registration 489
Cuban DH-4B	653/658 (6)	

• DH-4B – One hundred and eleven Liberty aircraft were delivered to Boeing for conversion to DH-4B, and all were redelivered to the Army between March 6 and July 1, 1920. The major improvement involved interchanging the positions of the fuel tank and the pilot's cockpit. The original between-cockpits location of the tank had done much to earn the Liberty aircraft its wartime nickname of 'Flaming Coffin'. Other changes involved moving the undercarriage forward slightly and minor equipment revisions. The DH-4Bs were given new Army serial numbers at the time of modification. This was common Army practice at the time, and some DH-4 airframes carried as many as four different military serial numbers between first flight and final salvage. Fifty of the original Boeing DH-4s were returned to Boeing in 1923 for further remodelling (still as DH-4Bs) and were given still another set of Army serial numbers as well as new Boeing serial numbers. Colouring was the standard olive drab all over.

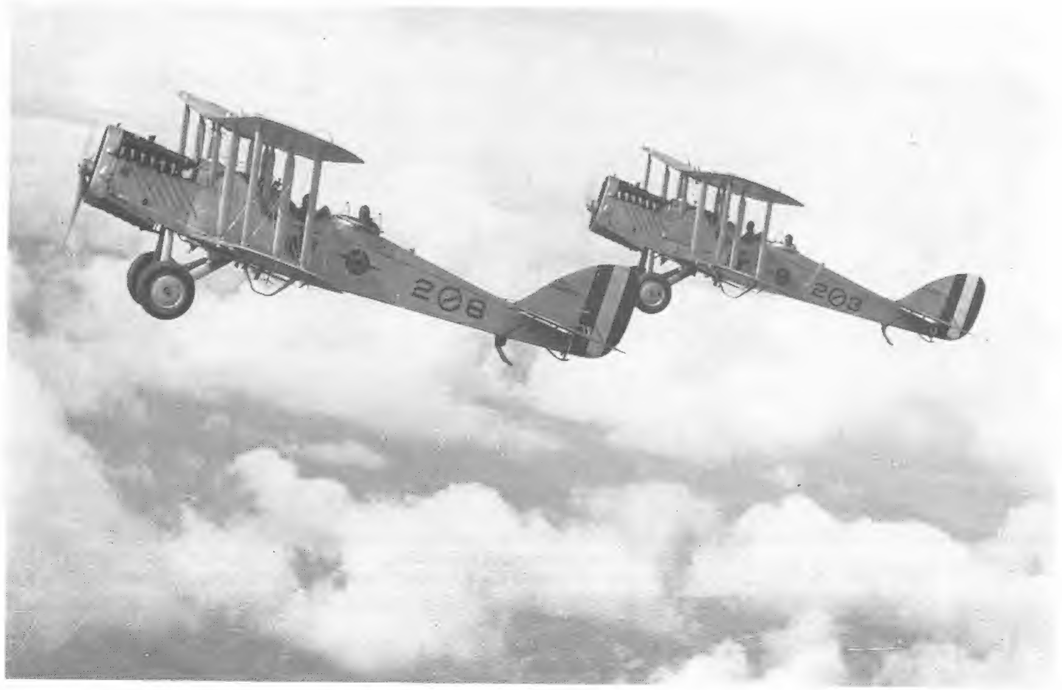
A Boeing-built DH-4M-1T dual control trainer in service at Brooks Field, Texas, in July 1929. Note Boeing-designed US Army rudder stripes adopted in 1926 and Boeing designation on fuselage. (*Courtesy Vic Stuhr*)



Marine Corps O2B-2 with the rounded turtledeck that identified the -2 variant. The Loening COA-1 wings shown were fitted to a number of DH-4s and O2Bs without affecting their designations. (*US Marine Corps Photo QN-417*)

• XDH-4M-1 – Under a contract signed in February 1923, Boeing undertook to equip three DH-4s with steel tube fuselages, using the Boeing-developed arc welding process, as XDH-4M-1. The letter M stood for Modernized. The machines were originally to have been plain DH-4M, but the prefix X was added later in Army records and the suffix designation -1 was added to distinguish the Boeing-built steel fuselages from those built by Fokker in his new American factory, the Atlantic Aircraft Corp. The Fokker-Atlantic models were DH-4M-2, and used the gas welding process. Outwardly, the DH-4Ms were indistinguishable from the earlier B model except for the fact that the fuselage was covered with fabric instead of plywood. Although produced on an earlier contract, the three XDH-4M-1s carried c/ns and Army serial numbers at the end of a later contract. The modification programme on the three prototypes cost $15,163.69

• DH-4M-1 (O2B-1) – Two additional contracts were received by Boeing for DH-4 modernization, one for 50 in June 1923 and one for 133 in July 1923. The sums involved were $157,000 and $263,300, respectively, and the machines were intended primarily for photographic purposes. Later, 22 were converted to dual-control trainers at Army depots and redesignated DH-4M-1T. Although the Army had adopted a standard designation system for aircraft well before the DH-4B and DH-4M orders, aircraft in existence before adoption of the system retained their original designation to the end of the service life of the type. In 1924, when the practice of painting the manufacturer's name on the rudder of Army aeroplanes began, and in 1927, when it appeared in the type designation on the side of the fuselage, the name Boeing DH-4M or DH-4M-1 was applied to the rebuilt aeroplanes just as though Boeing were the original manufacturer. Army DH-4M-1s were originally olive drab all over. Those in service after 1927 had wings and tail surfaces changed to orange-yellow.



Boeing-built DH-4M-1s delivered to US Marines were given naval designation of O2B-1. Navy colouring after 1920 was all silver with yellow top to upper wing and tail. (*US Navy Photo*)

The DH-4M-1s were delivered between January 21 and September 12, 1924. One Boeing DH-4M-1 was still flyable in 1989.

• O2B-1 – The last 30 DH-4M-1s were diverted to the US Marine Corps in Naval colouring and were redesignated O2B-1 under the prevailing Naval aircraft designating system (OB-1 had been assigned to a Navy-designed amphibian to have been built by Boeing. While the two aeroplanes, Navy serial number 6882 and 6883, were not built, the designation and serial numbers were not reassigned). The O2B-1s were delivered between March 10 and 31, 1925. Colour was all silver with orange-yellow upper surfaces on top wing and horizontal tail.

• O2B-2 – The last four O2B-1s (A-6924/6927) were converted by the Navy to cross-country configuration similar to Army Airways DH-4s, with lights, radio, flares, and generally more comfortable crew accommodation, and were given the designation of O2B-2.

MODEL 42 (XCO-7 Series) – Three DH-4M-1s were fitted with new Boeing designed tailplanes, tapered wings, and tripod undercarriages and were given the new Army designation of XCO-7 for Experimental Corps Observation Model 7. This was an attempt to extend the service life of the basic DH-4 model and make further use of the large quantity of DH equipment that was on hand. The performance increase did not justify the cost, and the Army turned to entirely new designs.

The XCO-7A, a standard Boeing-built DH-4M fuselage fitted with tapered wings, wider horizontal tail surfaces, and new landing gear of Boeing design. (*USAF McCook Field Photo 20577*)

• XCO-7 – The first XCO-7 did not fly, being used for static test.

• XCO-7A – The second was designated XCO-7A and used a completely standard DH-4M-1 fuselage and Liberty engine installation with the Boeing modifications.

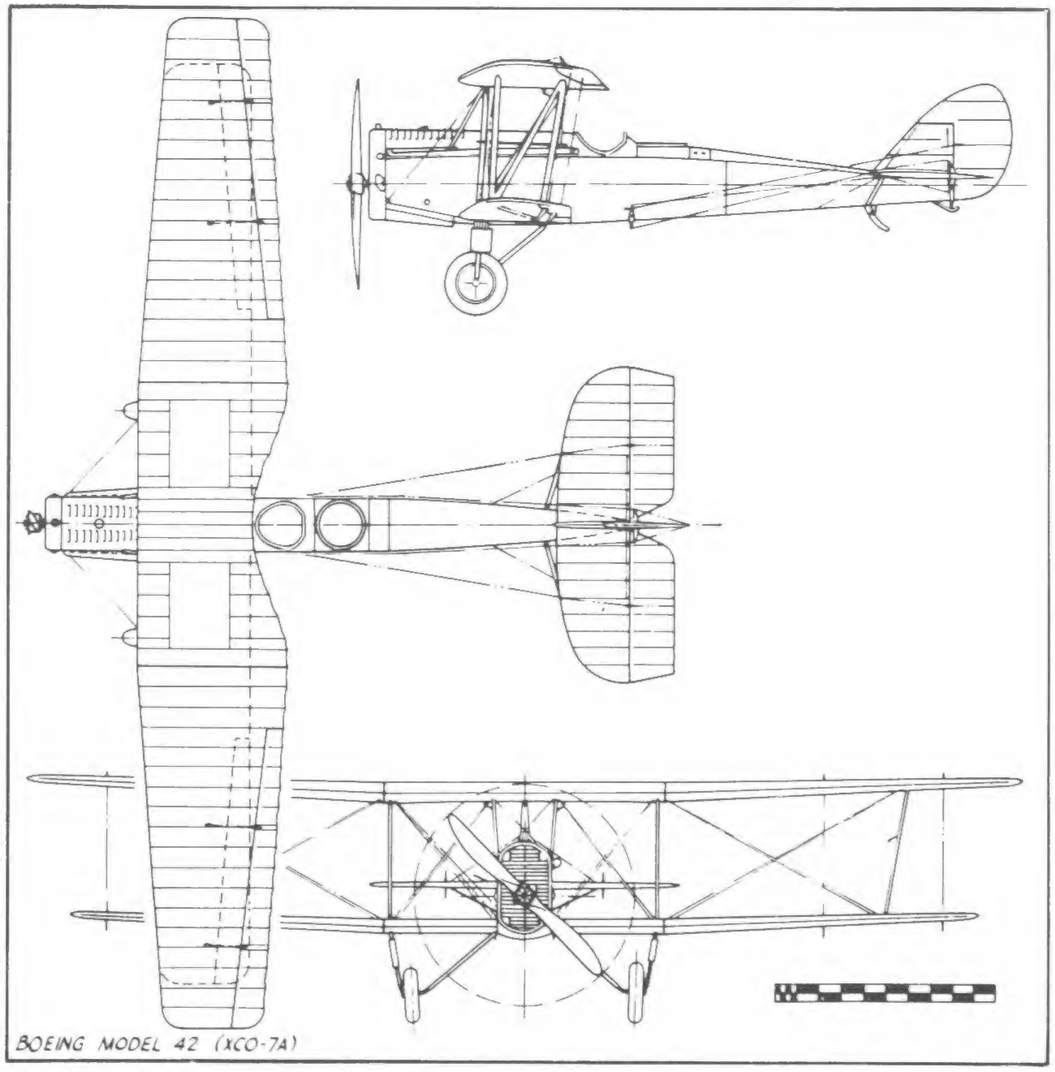
• XCO-7B – The third was designated XCO-7B and differed from the A in having balanced elevators and an inverted Liberty engine that the Army had been developing. Both flyable XCO-7s were shipped to McCook Field, where the first flight was made on February 6, 1925.

TECHNICAL DATA - XCO-7A

Type:	Observation
Accommodation:	2 in tandem
Power plant:	Liberty 12A, 420 hp
Span:	45 ft
Length:	29 ft 2 in
Height:	10 ft 8 in
Wing area:	440 sq ft
Empty weight:	3,107 lb
Gross weight:	4,665 lb
Max speed:	122 mph
Cruising speed:	110 mph
Climb:	810 ft/min
Service ceiling:	13,050 ft
Range:	420 miles
Armament:	Four ·30 cal MG

Model	*C/n*	*Army serial numbers*
XCO-7	520	22884
XCO-7A	519	23109
XCO-7B	521	31216

The XCO-7B, identical to the XCO-7A except for experimental inverted Liberty engine. The new components did little to improve the original DH-4 performance. (*Boeing Photo 756-B*)



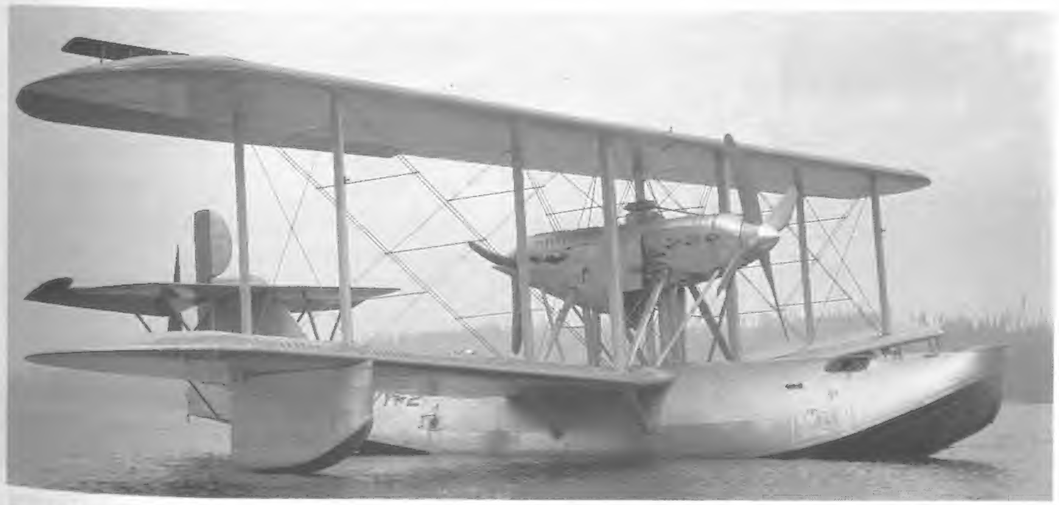
MODEL 50 – (PB-1, XPB-2) – the Boeing Model 50 was a US Naval Aircraft Factory flying-boat design that used the talents of a civilian designer then working for Consolidated Aircraft, the same Isaac Laddon who had designed the GA-1 and GA-2 when employed by the US Army. Boeing was left to complete much of the detail.

The design originated in September 1924, in response to a Navy requirement for a long-range twin-engine flying-boat capable of flying the 2,400 miles from San Francisco to Hawaii nonstop. The PB-1, as the Boeing-built aeroplane was designated, was conventional in layout except for the tandem engine arrangement. It was extremely clean aerodynamically compared to other flying-boats and was full of structural innovations that were to be significant to later Boeing designs.

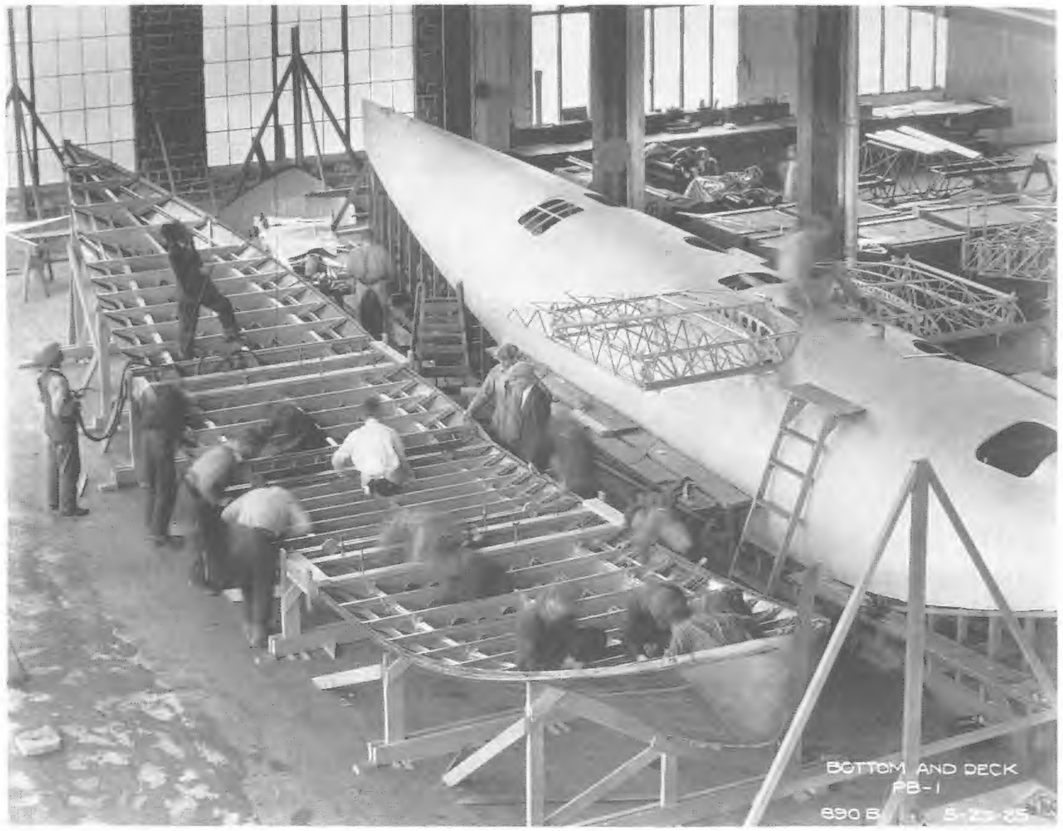
The wing spars were welded tubular trusses and the ribs were assembled from steel tubing and channel. The wing tips were built up of wooden ribs and tip bows with plywood covering, and the wing leading edges were wood. The hull construction was most unorthodox in that the lower portion was metal while the upper portion was built up of laminated wood frames covered with wood veneer. The aerofoil was the new Clark Y, developed by Col V E Clark of McCook Field. An aerodynamic innovation was the use of auxiliary aerofoil sections which were built above the ailerons to serve as aerodynamic balances in place of the more conventional horn balance as used on the rudder and elevators.

• PB-1 – The PB-1 was the original configuration of the Model 50 as fitted with water-cooled Packard 2A-2500 engines. It was intended that the PB-1 would be used in an attempt by the Navy to fly from California to Hawaii, but the PB-1 did not make the trip because another Navy team, flying the Navy-built PN-9, accomplished the feat in September 1925.

• XPB-2 – In 1928, the Naval Aircraft Factory replaced the water-cooled Packard engines of the PB-1 with new experimental geared P & W R-1860

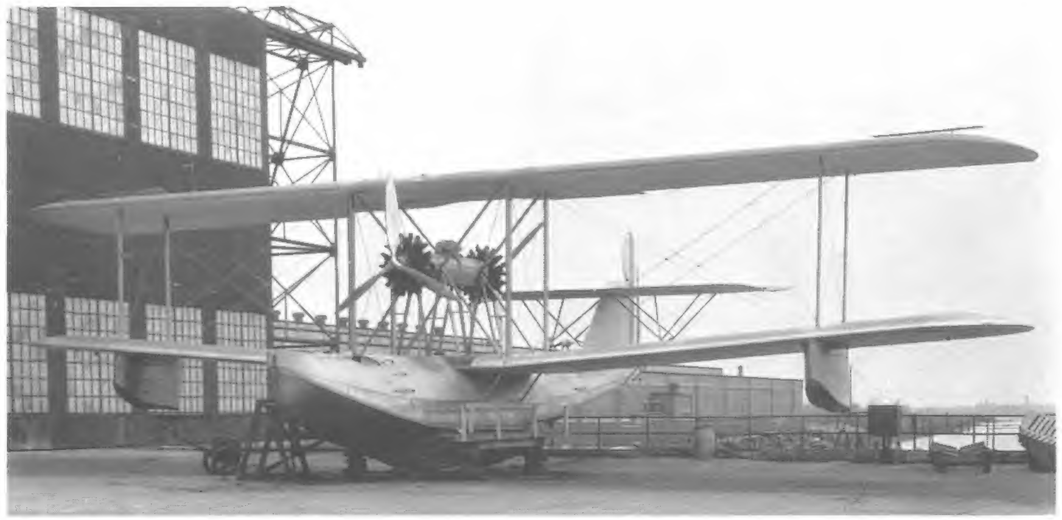


The single PB-1 (Boeing Model 50) flying-boat afloat on Lake Washington, August 14, 1925. (*Boeing Photo P-1031*)

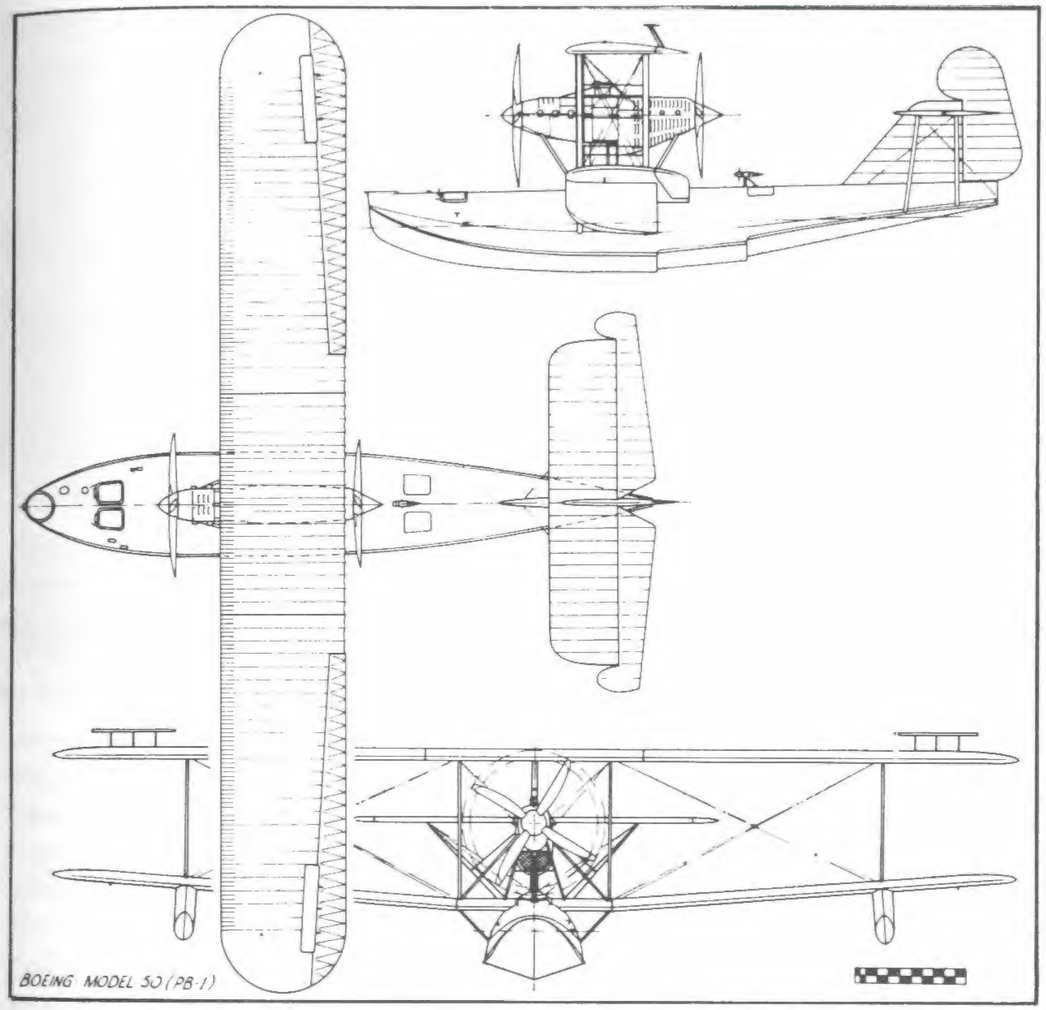


Assembling the unique wood-and-metal hull of the PB-1. (*Boeing Photo P-890-B*)

Hornet engines of 800 hp and redesignated the aeroplane XPB-2. While it had been built as an experimental model, the PB-1 did not carry the X prefix because the Navy did not distinguish experimental from standard models by designation at that time.



The Naval Aircraft Factory replaced the liquid-cooled Packard engines of the PB-1 with air-cooled geared Hornets and redesignated the aeroplane XPB-2. (*US Navy Photo*)

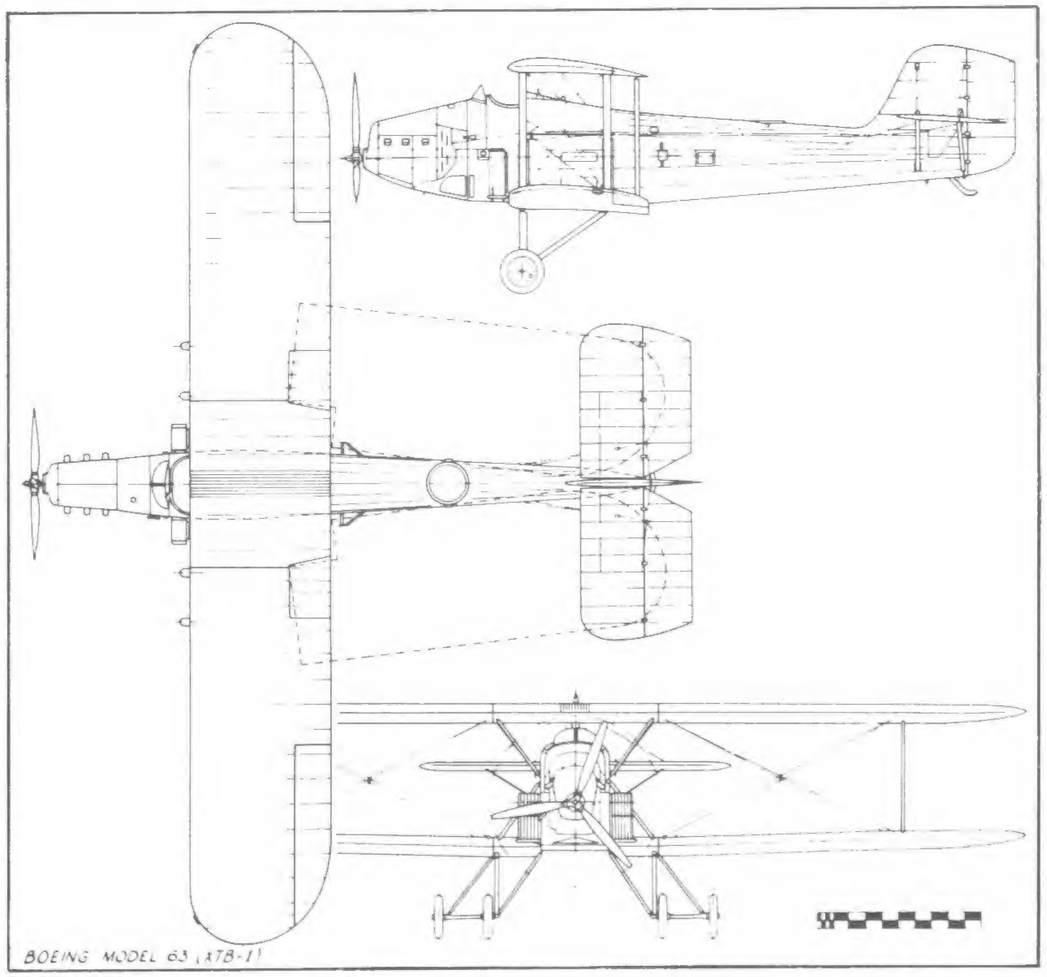


TECHNICAL DATA - PB-1

Type:	Patrol flying-boat
Accommodation:	5 crew
Power plant:	Packard 2A-2500, 800 hp
Span:	87 ft 6 in
Length:	59 ft 4½ in
Height:	20 ft 10¼ in
Wing area:	1,801 sq ft
Empty weight:	11,551 lb
Gross weight:	26,822 lb
Max speed:	112 mph
Cruising speed:	94 mph
Climb:	4000 ft/min
Service ceiling	9,000 ft
Range:	2,500 miles
Armament:	4,00 lb bombs, three ·30 cal MG
C/n:	801
Navy serial number:	A-6881

Landplane version of Navy-designed XTB-1 torpedoplane, Boeing Model 63. Separation of landing gear is to permit carrying of naval torpedoes under the belly. (*Boeing Photo P-1487-B*)

MODEL 63 (TB-1) – The three TB-1s were designed by the Navy and were the last non-Boeing designs built in Seattle until WW-II. The TBs were improved versions of an earlier Navy design that had been built by Martin as the T3M. Structure was all dural with fabric covering in place of



Seaplane version XTB-1. Note location of bombardier's station. X prefix was added retroactively to the first of the three TB-1 aircraft after Navy adopted the experimental prefix in 1927. (*Boeing Photo P-1493-B*)

the wood wings and the steel tube fuselage of the Martin. The pilot and bombardier/navigator occupied a side-by-side cockpit just aft of the engine, the bombing station was on the floor just ahead of the lower wing, and a rear gunner's station was located on the top of the fuselage between the wing and the tail. The wings folded aft at the rear spar-centre section strut junction, reducing the overall span to 21 ft 8 in for shipboard storage. The four-wheel undercarriage was divided to permit torpedoes to be carried under the fuselage and twin floats could be substituted for the wheels. The first TB-1, identified as XTB-1, flew on May 4, 1927, and all three were delivered in June for a total contract price of $199,000.

The XTB-1 A-7024 photographed on April 26, 1927. (*Boeing Photo 1494-B*)

Before the TB-1s were completed the Navy had decided against dependence on a single power-plant for such a heavy aeroplane and developed the basic design into a twin-engine model with only a 2 ft increase in wing span. This model, powered with two 525 hp Wright Cyclone radial engines, was built by Douglas as the T2D-1.

TECHNICAL DATA - TB-1

Type:	Torpedo
Accommodation:	Pilot, bombardier, gunner
Power plant:	Packard 3A-2500, 730 hp
Span:	55 ft
Length:	40 ft 10 in
Height:	13 ft 6 in
Wing area:	868 sq ft
Empty weight:	5,640 lb
Gross weight:	9,786 lb
Max speed:	115 mph
Cruising speed:	100 mph
Climb:	754 ft/min
Service ceiling:	12,500 ft
Range:	878 miles
Armament:	Two ·30 cal MG, one 1,740 lb torpedo
C/ns:	834/836
Navy serial numbers:	A-7024/7026

Chapter 3

ORIGINAL BOEING FIGHTERS

By the time the MB-3 order was well under way, Boeing engineers and shop personnel had gained sufficient experience with high-performance single-seaters to enable them to form their own opinions as to how a fighter should be designed and built. However, since the postwar orders for 50 Thomas-Morse MB-3s, 200 Boeing MB-3As, 50 Curtiss-Orenco Ds, and a few lesser models, had filled the Army's pursuit requirements, there was no government interest at the time in a new design and no official encouragement was received from that quarter.

Boeing's belief in the desirability of a better design was so strong that the company decided to go ahead and produce a new model on its own, gambling that demonstrated superiority would result in subsequent orders from both military services. This decision to speculate in the field of fighter design proved to be of great significance to the company, for, when coupled with a subsequent decision to pioneer in a type of construction new to American practice, the result was a design that not only won orders on its merits but proved to be the first of a long line of related single-seaters that was to become Boeing's principal source of income and make it the country's leading producer of fighters for a decade to come.

The all-wood construction of the MB-3s had produced many headaches from both the production and maintenance points of view, and there was plenty of evidence at hand that this method of construction, at least for

Unorthodox delivery. An FB-5 fighter stood on its nose and moved sideways out of the factory door for delivery by barge to an aircraft carrier in Seattle harbour. The first flights of these particular machines were made by Navy pilots from the deck of the carrier. (*Boeing Photos P-1400-B and P-1392-B*)

Boeing F2B-1 Navy fighters in formation with their lower wingtips tied together. Such flying was a feature of US Naval exhibition teams in the late 1920s. (*Courtesy Clyde P Matteson*)

fighter fuselages, was at the end of the line. Realizing this, Boeing engineers cast about for more suitable elements. All-aluminium alloy structures were considered, but while several had been produced during and after WW-I by other manufacturers, the state of the art had not advanced to the point where such structures were particularly efficient or even acceptable to the then highly-conservative military market. Boeing engineers even toured Europe to check on the latest developments. After examining all of the well-known products of the war years and all of the available postwar developments, they determined that welded steel tubing with semi-cantilever wood wings, as pioneered by the Dutch designer A H G Fokker in Germany during the war and continued in his Dutch factory after the armistice, was the most practical compromise between all-wood and more advanced methods of construction. Suitable examples of Fokker aircraft for further study were found to be available at home. The government had received many of the wartime Fokker D.VIIs under the terms of the armistice, and had shipped 142 of them to the United States for test and training purposes. Several were made available to industry for analysis, and three were delivered to Boeing, one for the use of the Army Air Service pilots at the factory and two for destructive tests. In spite of the handicaps imposed on German industry by the war, the Fokker had proved to be an outstanding aeroplane design. Its most radical features structurally were welded steel tubing for the fuselage and wooden cantilever box spars for the wings, the latter made possible by the use of an uncommonly thick aerofoil in place of the thin surfaces of contemporary designs. The steel fuselage greatly simplified the production and maintenance problems and the thick aerofoil gave excellent climb and altitude performance at the sacrifice of relatively little speed. The D.VII had made a very favourable impression on Army Air Service engineering personnel, as reflected by the reports that they issued following various stages of flight and static testing. These reports were available to US industry, and Boeing engineers, after reading them, came to realize that this general type of construction, actually several years old but entirely new to American production, would be acceptable to the Army. Consequently, work began on Boeing Model 15, a thoroughly conservative biplane to all outward appearance.

MODEL 15 (XPW-9, PW-9, FB-1) – The Model 15 was an entirely new fighter developed according to the Boeing concept of what a suitable fighter design should be like, and deliberately by-passed some of the requirements of the Army 'Bible', the Handbook of Instructions for Airplane Designers, that were considered restrictive to advanced designs.

As originally designed, the Model 15 used the same 300 hp Wright-Hispano engine as the MB-3A, was fitted with a nose radiator instead of the side-mounted type, and was to have had straight-chord wings tapered in thickness like those of the Fokker D.VII. Internal details of wing and fuselage were similar to the Fokker in that the wing spars were of built-up spruce flanges with mahogany plywood webs, the ribs were bandsawed to shape from 3-ply wood and reinforced with spruce cap strips, and the fuselage was of welded steel tubing braced with piano wire. The Fokker had used gas welding, but Boeing greatly simplified the manufacturing problem involved by developing a suitable arc-welding process. The tail differed from the Fokker in that the horizontal surfaces were of wood and of thicker section, and the tailplane could be adjusted in flight to trim the aeroplane. Assembly was simplified in that the lower wing was made up of two separate panels. Struts were of streamlined steel tubing rather than wood as had been normal American practice, and the influence of the D.VII was again evident in the arrangement of the centre section struts and the straight-axle undercarriage. Model 15 did not use the full 'extra wing' of the Fokker, but did streamline the axle with a small wing-like structure of 16 in chord.

Early in the design stage a more powerful power plant, the 12-cylinder liquid-cooled Curtiss D-12 of 435 hp became available and Model 15 was redesigned to accommodate it. Other significant changes were made at the same time: the wing planform was changed from straight chord to taper, the full-cantilever spars were modified to semi-cantilever with wire bracing while retaining the same structural characteristics and the thick Göttingen 436 aerofoil, and the radiator was relocated from the full-front position of some wartime and contemporary designs to a 'tunnel' position under the engine that was to become standard for most subsequent production American fighters with liquid-cooled engines.

Preliminary design details were finalized on January 10, 1922, and work began. Details of the new design were soon brought to the attention of the Army and succeeded in arousing interest to the point where a bailment contract for the testing of the new model was offered. This was not a purchase contract, nor did the assignment of a military designation for the aeroplane result from it. The contract merely specified that the Army would provide such military items as armament and power plant and would test the aeroplane. The airframe and all proprietary design rights were to remain Boeing property for the duration of the contract, which was signed on April 4, 1923. See table of specifications for Model 15 on pages 84–85.

• XPW-9 – The first example, referred to hereafter by the military designation of XPW-9 for Experimental Pursuit, Watercooled Design No.

9, even though this was not assigned to the aeroplane until a purchase contract was signed later in the year, was first flown on June 2, 1923, by Captain Frank Tyndall, an Army test pilot assigned to Boeing. After further testing by Boeing pilots at the factory, the first XPW-9 was sent by rail to McCook Field for extensive military testing. It was painted olive drab but, since it was a company-owned aeroplane, it carried no military markings.

The XPW-9 was flown in competition with the Dutch-built Fokker XPW-7 and the Curtiss XPW-8A, two other experimental fighters that the Army was testing, as well as the production PW-8 which the Army had just purchased as a standard model. Certain features of the Boeing, notably the tapered wing and the tunnel radiator, so impressed the Army that Curtiss was asked to try them on the XPW-8A, the third PW-8 prototype, which had originally been completed with straight wings having the radiator mounted in the centre section. The tunnel radiator was tried first on the XPW-8A, and when it appeared later with tapered wings the designation was changed to XPW-8B. This served as the prototype of the Curtiss Hawk series for the Army and Navy that started with the P-1 of 1925.

After testing the single Boeing pursuit on the bailment contract, the Army ordered two more on a standard purchase contract dated September 28, 1923, accepting the first one as Army property under the contract at that time and officially assigning the designation of XPW-9 to all three aeroplanes. The contract specified certain changes to be incorporated in the second and third examples to make them conform to standard air service specifications and procedures. These two left the factory in full military markings and were delivered to the Army on May 1, 1924. XPW-9 No. 1 had continued the test programme while the others were being built, and several improvements were made. A new Boeing-designed undercarriage with divided axle and oleo shock absorbers faired into the intersections of the Vee struts was later tested on No. 1, after initial delivery with the

The second prototype PW-9, later designated XPW-9, showing the indented upper wing leading edge and the cross-axle landing gear used on all three examples. This was the first Boeing-designed pursuit aeroplane. (*Boeing Photo P-709-B*)

Production PW-9 (Boeing Model 15) fitted with experimental metal wings built by Thomas-Morse to the original PW-9 planform. (*USAF McCook Field Photo 31667*)

Fokker-like straight axle. XPW-9 No. 1 was scrapped at McCook Field on February 21, 1925, after static test and No. 2 was static tested in October 1928. No. 3 was still flying in December 1928.

C/ns:	512/514
Army serial numbers:	23-1216/1218

• PW-9 – Testing of the XPW-9 indicated that the new model was desirable for both military services, so joint orders totalling 45 articles were drawn up. The Army ordered 31 from fiscal 1925 funds, 12 on September 19, 1924 and 18 on December 16. The last aircraft on the second contract (25-324) was converted to XP-4 as Boeing Model 58 and one other was diverted to the NACA laboratories for research to be conducted with a late model high-performance aeroplane.

The production models differed only slightly from the third prototype in matters of detail. The engine cowlings were of better streamline shape, the divided axle undercarriage with 28 × 4 in wheels was standard equipment, and the centre section fuel tank of the prototypes was eliminated. The wheels were changed in service to large 750 × 125 mm size. The first PW-9 was delivered on October 30, 1925, and the last on December 18. All but the first few and the NACA model, which were retained in the US for test and evaluation, were shipped to US bases in Hawaii and the Philippines. One PW-9 was fitted at McCook Field with all-metal wings built to PW-9 planform by Thomas-Morse, using a Clark Y aerofoil with corrugated dural on the upper surfaces and fabric on the under surfaces. This was not intended to improve the performance of the PW-9 but to provide direct comparison between the two types of construction.

The colour scheme was the then standard olive drab overall with black lettering, vertical tail stripes, and the star-in-circle insignia, except for the NACA model, which used the silver Navy colour scheme without stars on the wings but with the tail stripes. The Army models carried the Air Service serial number in black on each side of the fuselage and BOEING PW-9 in black across the rudder.

It is interesting to note that while the production version of the third

One of the 10 FB-1s, duplicates of the Army PW-9 used by the US Marine Corps as land-based fighters. The circle around the squadron letter distinguished USMC aircraft from similarly-coloured Navy models until 1937. (*US Navy Photo*)

Curtiss XPW-8, which had been modified as XPW-8B with tapered wings and a tunnel radiator based on those of the XPW-9, was built as P-1 under the new Army designation system of plain P-for-pursuit adopted in 1924, the old PW designation was retained for the Boeing model until production was completed with the PW-9D in 1928.

C/ns: 659/670, 720/737, 752
Army serial numbers: 25-295/324 (none for c/n 752)

• FB-1 – A total of 16 Boeing Model 15 fighters was ordered by the Navy, but only 10 were delivered as FB-1, engine changes resulting in new Navy and company designations for the others. The FB-1s were duplicates of the Army PW-9s except for naval colouring and minor details, and used the same factory designation as the Army models. While most naval fighters of the period were designed for shipboard use, the FB-1s were shore-based. The first FB-1 was delivered to the US Marine Corps on December 1, 1925, and the last on December 22. Nine of the ten were in service with the USMC Expeditionary Force in China, in June 1928. At least 5 returned to the US and were in service in San Diego in November 1929.

C/ns: 738/747
Navy serial numbers: A-6884/6893

TECHNICAL DATA – MODEL 15

Model	XPW-9	PW-9	FB-1
Type:	Fighter	Fighter	Fighter
Accommodation:	one	one	one
Power plant:	Curtiss D-12 435 hp at 2,300 rpm		
Span:	32 ft	32 ft	32 ft
Length:	23 ft 5 in	23 ft 5 in	23 ft 5 in

Army PW-9A (Boeing Model 15A), outwardly indistinguishable from the first production PW-9s. (*USAF Photo*)

Height:	8 ft 2 in	8 ft 2 in	8 ft 2 in
Wing area:	260 sq ft	260 sq ft	260 sq ft
Empty weight:	1,936 lb	1,936 lb	1,936 lb
Gross weight:	2,971 lb No. 1 2,835 lb No. 2 3,015 lb No. 3	3,120 lb	2,835 lb
Max speed:	160·9 mph	159·1 mph	159·1 mph
Cruising speed:	142 mph	142 mph	142 mph
Rate of climb:	2,055 ft/min	1,630 ft/min	1,630 ft/min
Service ceiling:	22,000 ft	18,925 ft	18,925 ft
Range:	390 miles	390 miles	390 miles
Armament:	One ·30 cal MG, and one ·55 cal MG or two ·30 cal MG. Two 122 lb bombs		

MODEL 15A (PW-9A) – Twenty-five improved PW-9s were ordered on October 26, 1925, under the designation of PW-9A. These changes were reflected in the basic Boeing model number by adding the letter A to correspond to the earlier model and the only noticeable outward change was that landing wires were doubled. The engine was the later Curtiss D-12C (V-1150-1).

The first PW-9A was delivered on June 19, 1926, and the last on February 4, 1927. Two aeroplanes of the original order were not completed as PW-9A; 26-374 was converted to AT-3, an experimental advanced trainer as Boeing Model 68, and 26-375 was completed as PW-9B.

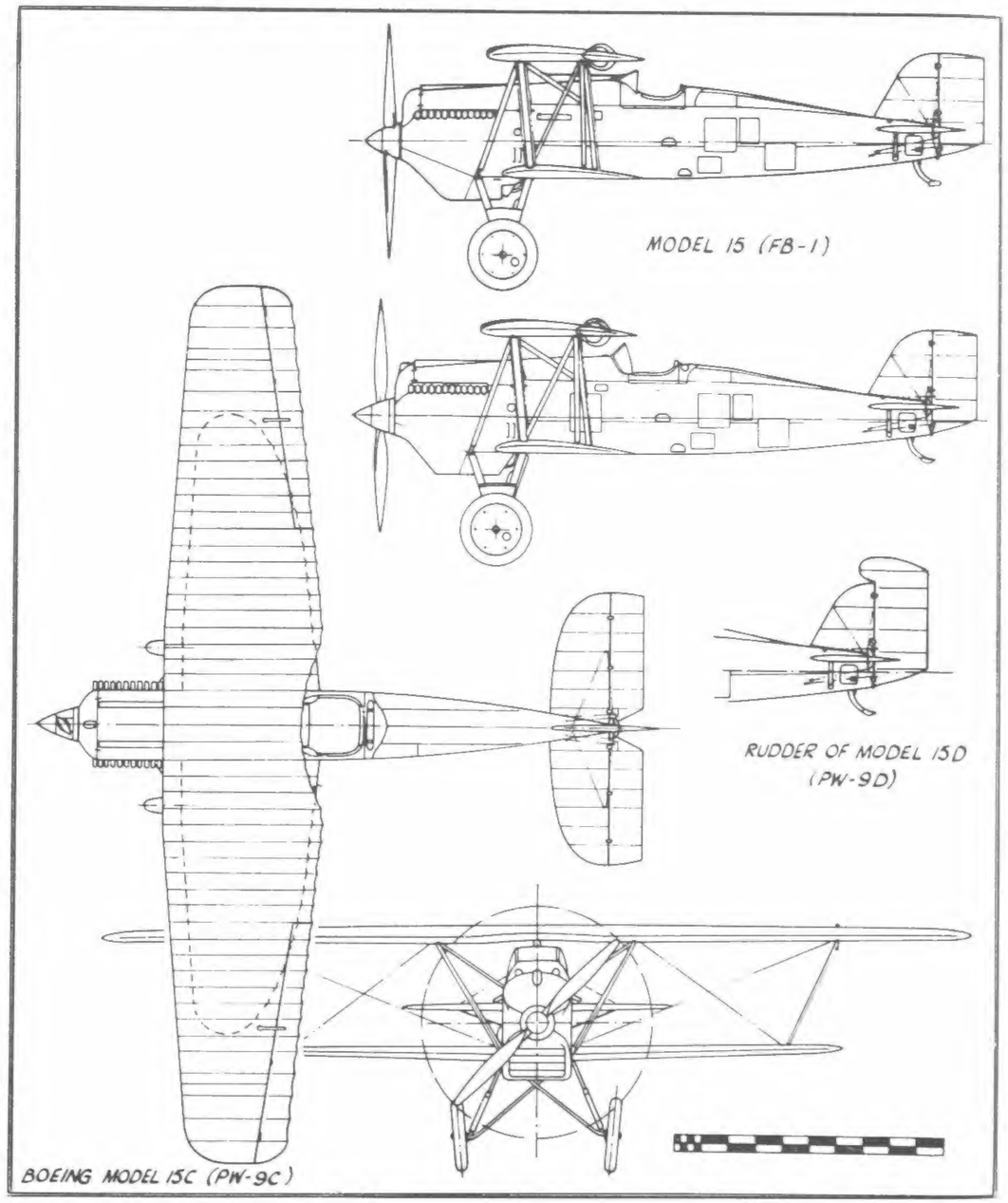
C/ns: 776/798
Army serial numbers: 26-351/373

MODEL 15B (PW-9B) – The last aeroplane on the PW-9A contract was completed as PW-9B to test a later Model D-12D (V-1150-3) engine and minor improvements. The contract for the conversion work was signed on October 26, 1925. Since the PW-9B differed so slightly from the PW-9As,

no official photographs were taken of it. Fifteen production PW-9Bs were to have been built, but their designation was changed to PW-9C because of a change in the military specification under which they were ordered. The prototype reverted to PW-9A with D-12C engine and was delivered to the Army as such on February 4, 1927.

C/n: 800
Army serial numbers: 26-375

MODEL 15C (PW-9C) – Two separate orders were placed for a total of 40 PW-9Cs. Fifteen were originally ordered on June 19, 1926, as PW-9B, but were later designated PW-9C, and 25 additional Cs were ordered on August



PW-9C with original small rudder, showing the distinctively American rudder stripe arrangement developed by Boeing and adopted for Army aircraft in 1926. The aeroplane colour was still overall olive drab. (*Boeing Photo 1536-B*)

18. Outwardly, the PW-9Cs were similar to the PW-9As except for rearranged flying and landing wire fittings, D-12D engine, and 32 × 6 in wheels, but the gross weight was increased mainly as a result of heavier fuselage structure.

The first PW-9C was delivered on July 9, 1927, but the tail stripes were changed from the old vertical three-stripe pattern to the new Boeing-developed arrangement adopted by the Army in November 1926. Originally, the PW-9Cs had the small unbalanced rudder of the prototypes and the PW-9A, but that was changed in service with those of the other production models to the balanced type developed on the experimental Navy FB-3 (Model 55). The last PW-9C (27-202) was converted to the prototype PW-9D on October 4, 1927.

C/ns: 837/876
Army serial numbers: 26-443/457, 27-178/202

PW-9D (Boeing Model 15D) was built with an enlarged rudder having aerodynamic balance area. This rudder was later fitted to all earlier PW-9 series aircraft in service. (*USAF Wright Field Photo 35222*)

Forward fuselage of a PW-9D with the cowling removed to show machine-gun and blast tube installation. Compare the size of ·50-calibre gun on right with ·30-calibre on left, and note the narrow instrument panel. (*Boeing Photo 1940-B*)

MODEL 15D (PW-9D) – The first PW-9D was converted from the last PW-9C to test changes that were to be incorporated in the 16 production PW-9Ds but retained the D-12D engine. Major improvements included a pressure fire extinguisher system, redesigned radiator and shutters, 30 × 5 in wheels with heel-controlled brakes, and an aerodynamically-balanced rudder of increased area duplicating that developed on the FB-3 (Model 55). This rudder was later fitted to most of the PW-9s including Cs already in service. The first experimental PW-9D was shipped to Wright Field, which had replaced McCook Field as the Army Air Corps Test Centre in 1927, on August 9, 1927, and made its initial flight there. The entire production order was delivered between April 25 and May 18, 1928, except for the last aircraft (28-41) which was kept at the factory for conversion to XP-7 (Boeing Model 93). The last PW-9D in service was surveyed in February 1934.

In anticipation of placing further orders for PW-9s, the Army established the designation of PW-9E and Boeing undertook engineering on Model 15E, but the project was cancelled when a new design then under development (Boeing Model 83/89) gave indication of being more desirable.

C/ns: 876, 1011/1026
Army serial numbers: 27-202, 28-26/41

MODEL 53 (FB-2) – The naval designation of this model indicated only that it was the second version of Boeing's first Navy fighter model, but the changes were sufficient for the company to justify the use of an entirely new

model number. Actually, the changes were much less than those between the first production Model 15 (PW-9) and the Model 15D (PW-9D).

Basically the two FB-2s were identical to the earlier FB-1 except for the structural modifications necessary to accommodate arrester gear for operation on aircraft carriers. Outwardly, the only structural differences were the use of a cross-axle type of undercarriage on the FB-2 with oleo shock absorbers in the front struts and carrier deck guide wire hooks mounted on the axle. Empty weight increased to 2,328 lb and gross weight

The only known photo of an FB-2 (Boeing Model 53), showing the arrester hook and modified landing gear that distinguish it from the otherwise identical FB-1. (*Boeing Photo P-1090-B*)

to 3,145 lb. High speed was 164 mph and landing speed was 59 mph. Both FB-2s were delivered to the Navy on December 8, 1925.

C/ns: 748, 749
Navy serial numbers: A-6894, 6895

MODEL 54 (FB-4, FB-6) – The FB-4 was the last aeroplane on the initial order for 14 naval equivalents of the Army PW-9 but carried Boeing Model 54, while the FB-3s, earlier in naval designation, were known as Boeing Model 55. The sequence of the factory model numbers does not reflect sequence of design development in this case – both were variations of the basic Model 15 and different numbers were arbitrarily assigned to distinguish between nearly-identical aeroplane projects using different power plants. After delivery, the Navy converted the FB-4 to FB-6 by changing the engine

• FB-4 – The FB-4 differed from the FB-2s mainly in being fitted with a new radial engine design, the Wright P-1, 450 hp predecessor of the famous Wright Cyclone, and in having provision for hoisting gear on the upper wing and the installation of twin wooden floats for operation as a seaplane.

The single FB-4 (Boeing Model 54), identical to the FB-1 except for floats and installation of an experimental air-cooled Wright P-1 450 hp radial engine. Note the two-year error in photo date. (*Boeing Photo P-1124-B*)

The radial engine resulted in a shorter overall length, 22 ft 10 in, but weights and performance were generally similar to the FB-1s. The single FB-4 was delivered to the Navy in January 1926.

C/n: 751
Navy serial number: A-6896

• FB-6 – The test programme of the FB-4 proved that the new Wright radial was not suitable for use on a fighter, so the Navy substituted the new 400 hp Pratt & Whitney Wasp radial, similar in size and weight to the P-1, and changed the designation of the aeroplane to FB-6. As originally installed,

The Navy became dissatisfied with the performance of the P-1 engine after delivery of the FB-4, so installed a Pratt & Whitney Wasp engine and redesigned the aeroplane as FB-6. (*US Navy Photo*)

the Wasp was fitted with a large spinner similar to that used on the P-1 engine but more sharply pointed. This was soon removed. With the Wasp, the FB-6 had a gross weight of 2,737 lb, 278 less than the FB-4 and had the same speed with 50 less hp.

The Wasp proved to be an outstanding engine and was used in new fighters produced for both services as late as 1934 and for trainers until the end of WW-II. The advantage of an air-cooled radial engine from the weight, maintenance, and supply standpoints was quite obvious, and once the reliability of the basic engine had been established, the Navy moved to standardize the type for all ship-based aircraft and withdrew even late-model liquid-cooled types from fleet service in 1928.

One of three FB-3s (Boeing Model 55), identical to the FB-1 except for the installation of the larger 510 hp Packard 1A-1500 engine. The increased power required the use of a larger balanced rudder similar to those of the later FB-5 and PW-9D models. (*US Navy Photo*)

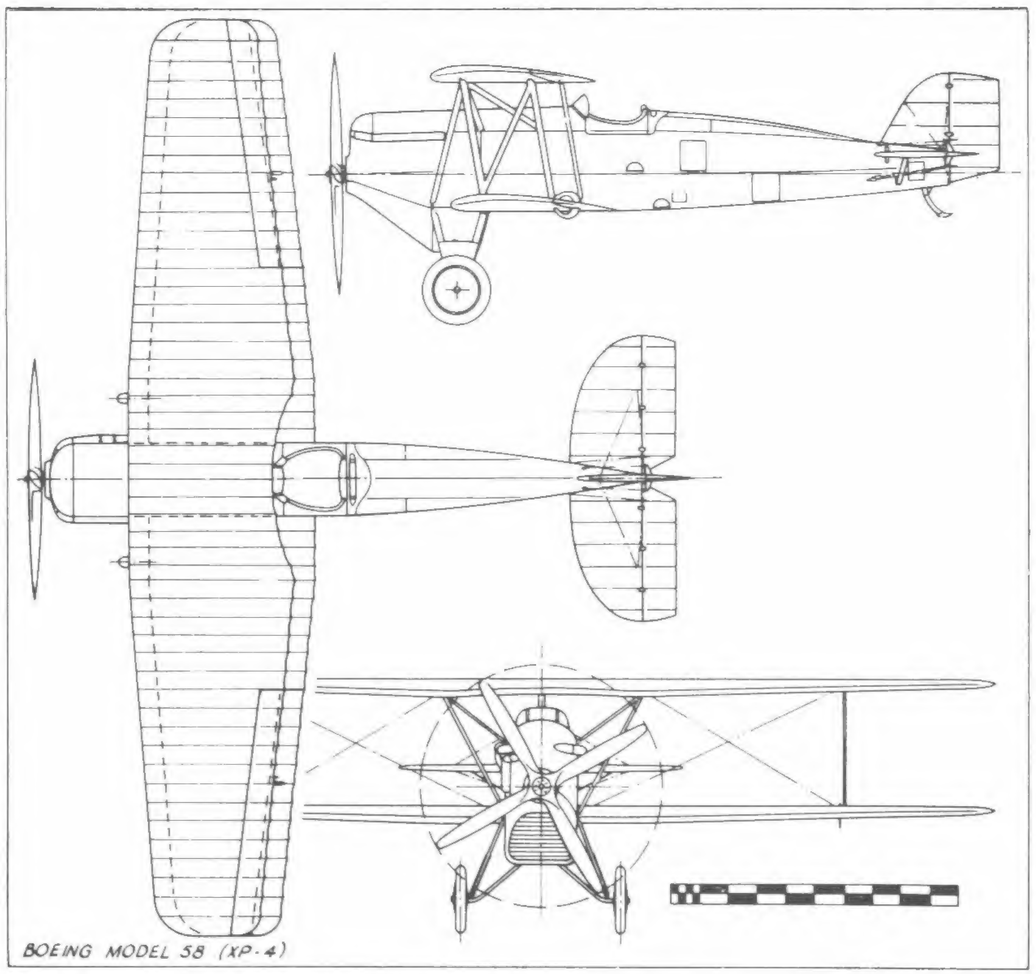
MODEL 55 (FB-3) – The first FB-3 was the 13th aeroplane on the initial 14-aircraft Navy order, but two additional FB-3s were added later. These were essentially FB-2s with FB-1 undercarriage and provisions for hoisting gear and twin floats. The engine was a 510 hp Packard 1A-1500. While this was a water-cooled V-12 very similar to the Curtiss D-12 in the PW-9s and the earlier FBs, it was larger and heavier and produced a noticeable change in the shape of the nose cowling. The first FB-3, fitted with twin wooden floats, was destroyed in December 1925, when the pilot misjudged his altitude over smooth water and flew into Lake Washington.

The last two FB-3s were procured on experimental Navy funds at $10,095 apiece less engines, and used mainly for test and development work after delivery in April 1926. The engines were $10,000 each additional. Originally the FB-3s used regular PW-9/FB-1 rudders, but were later fitted with a larger balanced design that became standard for the entire series. Performance and weight were comparable to earlier FBs but one FB-3 established a closed-course speed record of 180 mph for standard service fighters at the 1926 National Air Races.

C/ns: 750, 802, 803
Navy serial numbers: A-6897, 7089, 7090

The XP-4 (Boeing Model 58) was an experimental pursuit design created by fitting an enlarged lower wing and a supercharged engine to the last PW-9 airframe. (*USAF McCook Field Photo 31600*)

MODEL 58 (XP-4) – The XP-4 was the last PW-9 converted to a new experimental design through addition of a turbo-supercharger to a Packard engine and the substitution of a new lower wing having the same dimensions



as the original PW-9 upper wing in place of the regular 22 ft 5 in lower wing. There was no increase in the gap between the wings. The aerofoil section was changed from the original Göttingen 436 to a new Boeing 103A section. The armament was revised by installing one ·30 calibre gun in each lower wing far enough outboard to clear the propeller.

The XP-4 was 815 lb heavier than the PW-9 but had only 46 sq ft of additional wing area. It was severely handicapped in that it was merely an adaption of an existing aeroplane to a new configuration instead of having been designed for the best utilization of the new features. The XP-4 was delivered to Wright Field on July 27, 1926, and was surveyed on May 1, 1928, since it was of no further use as a test aeroplane and was too different from standard models for a service or advanced training squadron.

TECHNICAL DATA – XP-4

Type:	Fighter
Accommodation:	1 pilot
Power plant:	Supercharged Packard 1A-1500, 510 hp
Span:	32 ft
Length:	23 ft 11 in
Height:	8 ft 10 in
Wing area:	309 sq ft
Empty weight:	2,783 lb
Gross weight:	3,650 lb
Max speed:	160·9 mph
Cruising speed:	137 mph
Climb:	2,055 ft/min
Service ceiling:	22,000 ft
Range:	375 miles
Armament:	Two ·30 cal MG
C/n:	737
Army serial number:	25-324

MODEL 66 (XP-8) – The XP-8 was a new design initiated by Boeing to conform to an Air Corps specification issued in April 1925, for a fighter to be powered with a new inverted Packard 2A-1500 engine of 600 hp. It was built on a bailment contract which provided that the Army would supply the engine and military equipment and test the aeroplane, which would remain Boeing property. The aeroplane was delivered in July 1927, as Boeing Model 66 but carried military markings, including the new horizontal Army tail stripes but the old all-olive drab finish. The new Army colour scheme of olive drab fuselage and struts and chrome yellow wings and tail was later applied by the Army. The military designation of XP-8 and the Air Corps serial number was not officially assigned until the aeroplane was acquired by the Army for $15,000 on a separate purchase contract signed in January 1928.

Boeing Model 66 was developed at company expense and tested by the Army on a bailment contract. When purchased, the single prototype was given the designation of XP-8. (*USAF Wright Field Photo 32820*)

Except for the engine installation, the XP-8 drew heavily on the earlier PW-9s and FBs for design detail. The most unusual feature was the installation of the radiator in the centre section of the lower wing, which was carried below the lower longerons. The span of the upper wing was reduced by almost two feet from the PW-9 while that of the lower wing was increased by the same amount. The type of wing and fuselage construction was the same except that diagonal tubing replaced the wire bracing between the aft fuselage bays. The undercarriage incorporated the oleo-pneumatic shock absorbers in the forward struts as on the FB-2. This became a standard feature on subsequent Boeing fighters. While the XP-8 was not accepted as a service model, many of the structural improvements and refinement of line that first appeared on it were retained by later production models, notably the Model 69 (F2B-1). The XP-8 was surveyed at Wright Field in June 1929.

TECHNICAL DATA - XP-8

Type:	Fighter	*Service ceiling:*	23,000 ft
Accommodation:	1 pilot	*Range:*	325 miles
Power plant:	Packard 2A-1500, 600 hp at 2,500 rpm	*Armament:*	One ·30 cal MG, one ·50 cal MG
Span:	30 ft 1 in		
Length:	22 ft 10 in	*C/n:*	806
Height:	10 ft 9 in	*Army serial number:*	28-359
Wing area:	243 sq ft		
Empty weight:	2,390 lb		
Gross weight:	3,421 lb		
Max speed:	173·2 mph		
Cruising speed:	148 mph		
Climb:	2,138 ft/min		

The first FB-5 (Boeing Model 67), essentially a production version of the Packard-powered FB-3 with increased wing stagger and a redesigned landing gear. Note the small rudder. (*Photo by Arthur Price*)

MODEL 67 (FB-5) – The FB-5 was the major production model of the FB series. The first FB-5 flew on October 7, 1926, and all 27 were delivered to the Navy on January 21, 1927. The delivery was unique in that the aeroplanes were rolled out of the narrow factory doors after being stood on their noses on dollies, and were loaded on waiting barges and ferried directly to the aircraft carrier *Langley* in Seattle Harbour. The factory was some distance from the flying field, and normal delivery procedure was either to truck dismantled aeroplanes to the field and set them up there for flyaway delivery or to ship dismantled aeroplanes in crates directly from the factory to the customer.

Women were the fabric experts at Boeing. Here they prepare the fuselage of an FB-5 for covering, January 13, 1927. (*Boeing Photo 1393-B*)

The FB-5 differed considerably in appearance from the earlier FBs. The cowling was similar to that of the Packard-powered FB-3, but the rearrangement of the wings provided the principal point of recognition. The stagger was increased by moving the upper wing forward slightly while moving the lower wing aft, and a second set of flying wires was attached to the rear wing spar. A completely new undercarriage was developed so that the strut would still attach to the fuselage at the front lower wing spar fitting. For high-impact landings on aircraft carriers, the axles pivoted about the point of a rigid triangle below the fuselage. The land-based FB-5s used by the US Marines had undercarriages similar to those of the FB-1s. The first FB-5 built retained the unbalanced rudder of the earlier PW-9s and FBs, but production was completed with aerodynamically balanced rudders of increased area developed on the FB-3s.

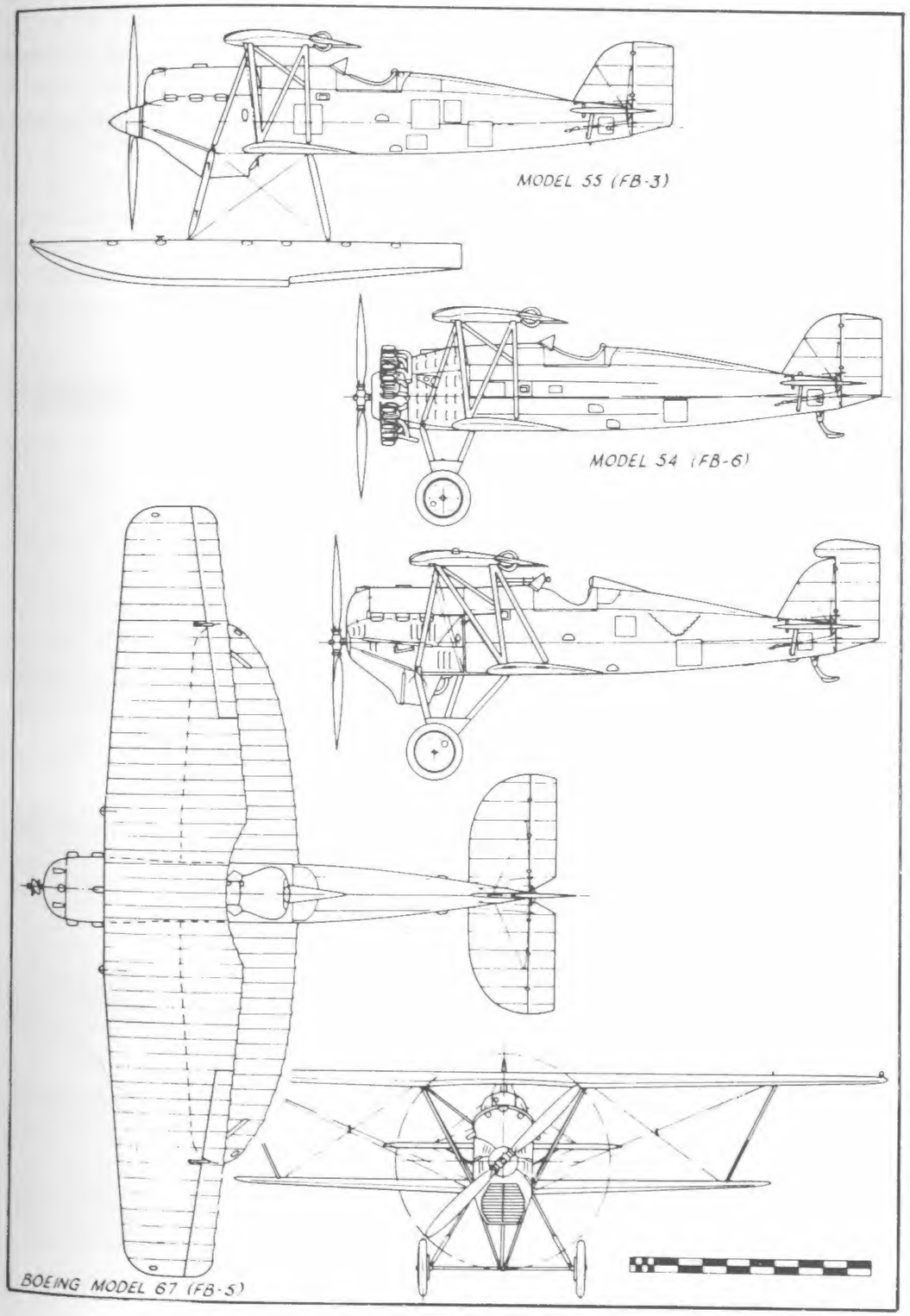
In spite of being a satisfactory shipboard fighter by prevailing standards, the FB-5s were retired after only a couple of years' service as a result of the Navy's decision to concentrate entirely on the air-cooled radial engine for shipbased aircraft. Since they were still up-to-date aeroplanes, most of the surplus FB-5s were given to service and civilian schools as non-flying instructional items. Two FB-5s still exist, one in the US Marine Corps Museum at Quantico, Virginia, and the other awaiting restoration and parts replacement at the Planes of Fame Museum at Chino, California.

The excellent performance turned in by the Pratt & Whitney Wasp engine installed in the converted FB-6 by the Navy indicated the desirability of installing the same engine in other designs then using the water-cooled Packard. Boeing initiated a modification to the FB-5 as Model 67A, and the Navy assigned it the official designation of FB-7. The design was never completed, however, because Model 69, a new design then being developed specifically for the Wasp, held greater promise.

The first FB-5 as a seaplane in October 1926, with the balanced rudder that became standard for all FB-5s. The Navy redesignated this particular machine XFB-5 in 1927. (*Boeing Photo P-1382-B*)

TECHNICAL DATA - FB-5

Type:	Shipboard fighter
Accommodation:	1 pilot
Power plant:	Packard 2A-1500, 520 hp at 2,100 rpm



Span:	32 ft
Length:	23 ft 10 in
Height:	9 ft 5 in
Wing area:	241 sq ft
Empty weight:	2,458 lb (land) 2,802 lb (sea)
Gross weight:	3,249 lb (land) 3,593 lb (sea)
Max speed:	175 mph (land) 176 mph (sea)
Cruising speed:	150 mph (land)
Climb:	2,100 ft/min (land) 1,860 ft/min (sea)
Service ceiling:	22,000 ft (land) 17,800 ft (sea)
Range:	420 miles (land)
Armament:	One ·30 cal MG, one ·50 cal MG
C/ns:	807/833
Navy serial numbers:	A-7101/7127

FB-5 for USMC with FB-1 type landing gear instead of aircraft carrier undercarriage. (*US Navy Photo*)

MODEL 68 (AT-3) – The AT-3 was the next to last aeroplane of the PW-9A order converted to an experimental single-seat advanced trainer by substitution of a 180 hp war-surplus Wright-Hispano Model E engine for

The single AT-3 (Boeing Model 68) was the next-to-last PW-9A fitted at Army request with a 180 hp Wright-Hispano engine for test as a single-seat advanced trainer. (*Boeing Photo P-1224-B*)

the 435 hp Curtiss D-12. This change was made at the request of the Army and was duplicated by Curtiss when the same type of engine was installed in a Curtiss P-1A fighter airframe, creating the AT-4.

The resulting trainers were considerably lighter than the fighters and, with less than half the horsepower, were considerably slower. The high speed of 129.3 mph for the AT-3 does not compare favourably with WW-I fighters powered with the same engine until allowance is made for the greater size of an aeroplane designed to carry a 435 hp engine and the use of a structure designed to military load factors at that power and weight. Since the structural elements of the AT-3 and 4 were not reduced in proportion to the power, the trainers were neither as fast nor as manoeuvrable as they could have been if designed for the purpose. Empty weight was 1,903 lb and gross was 2,648 lb. The general unsuitability of the conversion is reflected by the fact that most of the 35 production AT-4s ordered from Curtiss were soon converted to P-1Ds by installation of D-12 engines.

C/n:	799
Army serial number:	26-374

MODEL 69 (XF2B-1, F2B-1) – Model 69, tested by the Navy as XF2B-1 and put into production as F2B-1, was a direct development of the Model 66 using the power plant installation developed by the Navy on the FB-6. Fuselage structure differed slightly from the XP-8 in that the vertical and diagonal tubes aft of the cockpit were bolted to tabs welded to the longerons. As in the XP-8, wire was retained only for side-to-side bracing within each bay and a centre section for the two lower wing panels was built below the lower longerons.

• XF2B-1 – The new prototype fighter first flew on November 3, 1926, and received the Navy designation of XF2B-1, the Navy having just adopted the

Boeing Model 69 as submitted to the Navy for test in October 1926, before it was purchased as XF2B-1. The Boeing Bug used on the aeroplane while it was still company-owned is just visible on the side. (*Boeing Photo P-1375-B*)

The production F2B-1 differed from the prototype in deleting the propeller spinner, revising the undercarriage, and adding rudder balance area. This example, A-7429, is the leader of Navy Bombing Squadron VB-2B. (*US Navy Photo*)

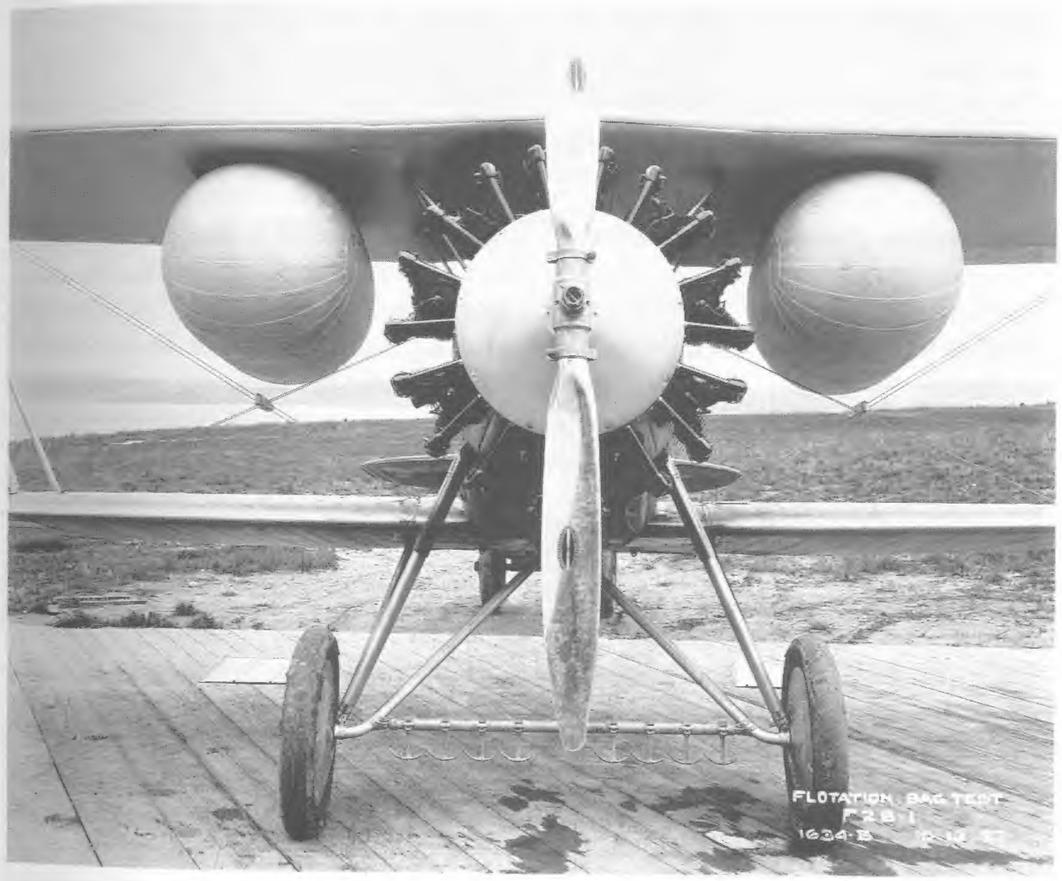
Army practice of identifying experimental prototypes with the letter X placed before the model designation. The nose of the XF2B-1 was faired with a large propeller spinner similar to that of the original FB-4 installation but the feature was not adopted for the production models. The rudder was unbalanced. Complete cost of the prototype, delivered to the Navy with all equipment, was $32,250.

TECHNICAL DATA - XF2B-1

Type:	Shipboard fighter
Accommodation:	1 pilot
Power plant:	P & W R-1340 Wasp 425 hp at 1,900 rpm
Span:	30 ft 1 in
Length:	23 ft
Height:	8 ft 9½ in
Wing area:	247 sq ft
Empty weight:	1,854 lb
Gross weight:	2,670 lb
Max speed:	154 mph
Cruising speed:	130 mph
Service ceiling:	21,550 ft
Range:	330 miles
Armament:	One ·30 cal MG, one ·50 cal MG, or two ·30 cal MG, five 25 lb bombs
C/n:	805
Navy special number:	A-7385

• F2B-1 – Thirty-two production F2B-1s were ordered as a result of Navy testing of the prototype,. and deliveries of this somewhat heavier aeroplane

began on January 30, 1928. Principal outward changes were deletion of the propeller spinner and the addition of a balanced rudder similar to that of the FB-3/5. As an example of the reduced costs achieved by quantity production, the price of an F2B-1, less Government Furnished Equipment (GFE), was $12,650. 1927 price for the P & W R-1340 Wasp engine was $7,730. While the F2B was essentially a fighter aeroplane and carried a fighter designation, it was also used as a bomber by Navy Squadron VB-2B,



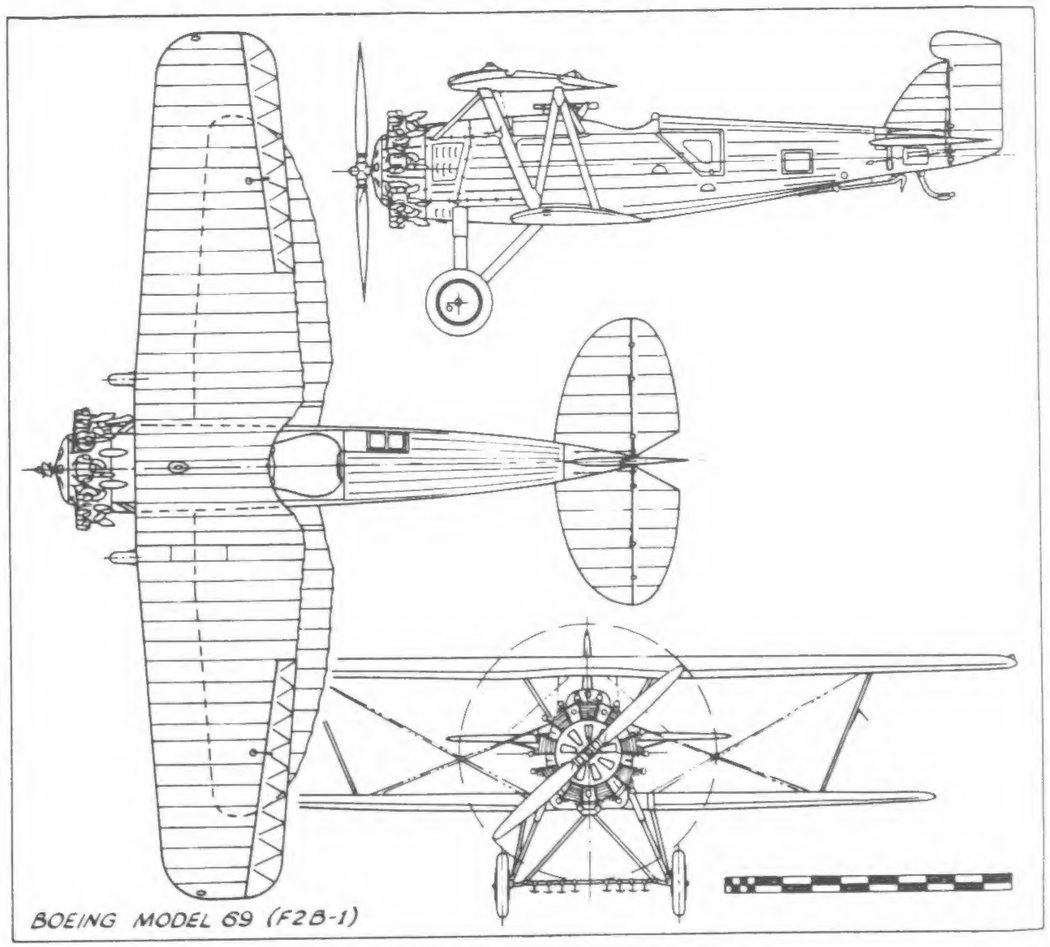
In spite of having a divided-axle undercarriage, early F2B-1s used a rigid spreader-bar to carry the hooks that guided the aeroplane along the longitudinal deck wires then in use on US Navy aircraft carriers. Note the inflated flotation bags. (*Boeing Photo 1634-B*)

which had been a fighter squadron, VF-6B.

The F2B-1, in company with other contemporary American designs, had no opportunity to demonstrate its worth in actual combat, but it did earn a unique peacetime reputation as an aerobatic aeroplane in the hands of the Three Sea Hawks, the Navy's first precision aerobatic team, which performed at the National Air Races and other air shows. This team was able to take off, manoeuvre, and land with the wing tips of the three aircraft joined by 50 ft lengths of rope festooned with cloth streamers for increased visibility from the ground. This technique was eventually expanded to the point where a whole squadron would fly and land tied together.

TECHNICAL DATA - F2B-1

Type:	Shipboard fighter
Accommodation:	1 pilot
Power plant:	P & W R-1340 Wasp 425 hp at 1,900 rpm
Span:	30 ft 1 in
Length:	22 ft 11 in
Height:	9 ft 2¾ in
Wing area:	243 sq ft
Empty weight:	1,989 lb
Gross weight:	2,805 lb
Max speed:	158 mph
Cruising speed:	132 mph
Climb:	1,890 ft/min
Service ceiling:	21,500 ft
Range:	317 miles
Armament:	as XF2B-1
C/ns:	904/935
Navy serial numbers:	A-7424/7455



Boeing Model 69-B was export version of the Navy F2B-1. Two were built, the one shown here carrying Japanese military markings. The other was flown to Brazil. (*Courtesy Shiro Ogiwara*)

MODEL 69-B – While the Navy F2B-1s were being built, authorization was obtained for Boeing to build two additional F2B type aeroplanes, to be known as Model 69-B, for export. Specifications and performance were identical to the production F2B-1s. One, c/n 1034, was sold to Japan and the other crashed in bad weather while being flown to Brazil for demonstration flights.

C/ns: 1034, 1035

MODEL 74 (XF3B-1) – Model 74 was built by Boeing as a private venture and submitted to the Navy for test as XF3B-1. Outwardly, it resembled a production F2B-1 (Boeing 69) with an FB-5 undercarriage and XF2B-1 rudder that was changed to production F2B type early in the factory flight-test programme. The XF3B-1 could also be fitted as a seaplane, but instead of using the twin float arrangement of the earlier FBs it had a single float under the fuselage and two wing tip floats in the manner of the standard Navy observation seaplanes that could be catapulted from battleships. Navy interest in this float arrangement for fighters is reflected by the fact that the earlier Vought FU-1 and the contemporary Eberhart XFG-1, Wright XF3W-1, and Curtiss XF7C-1 could also be fitted with single floats. However, these five machines marked the end of Navy interest in seaplane fighters until a single experiment with twin floats on a Grumman F4F-3 took place in 1942.

The XF3B-1 first flew on March 2, 1927, but did not carry either civil or military markings when tested by the Navy other than the Army type tail stripes developed by Boeing, and the new Boeing Bug as company insignia (see page 27).

The XF3B-1 did not show a sufficient improvement over the F2B-1 to justify production as a new fighter type, so it was returned to the factory, still as Boeing property, where it was rebuilt into a new design fighter-bomber (Model 77). It was then purchased by the Navy as an additional article on a contract for 73 production Model 77s designated F3B-1.

Boeing Model 74 was tested by the Navy as XF3B-1 but never became Navy property in that configuration. Note the Boeing-developed 'Army' tail stripes. (*Boeing Photo 1437-B*)

TECHNICAL DATA - XF3B-1

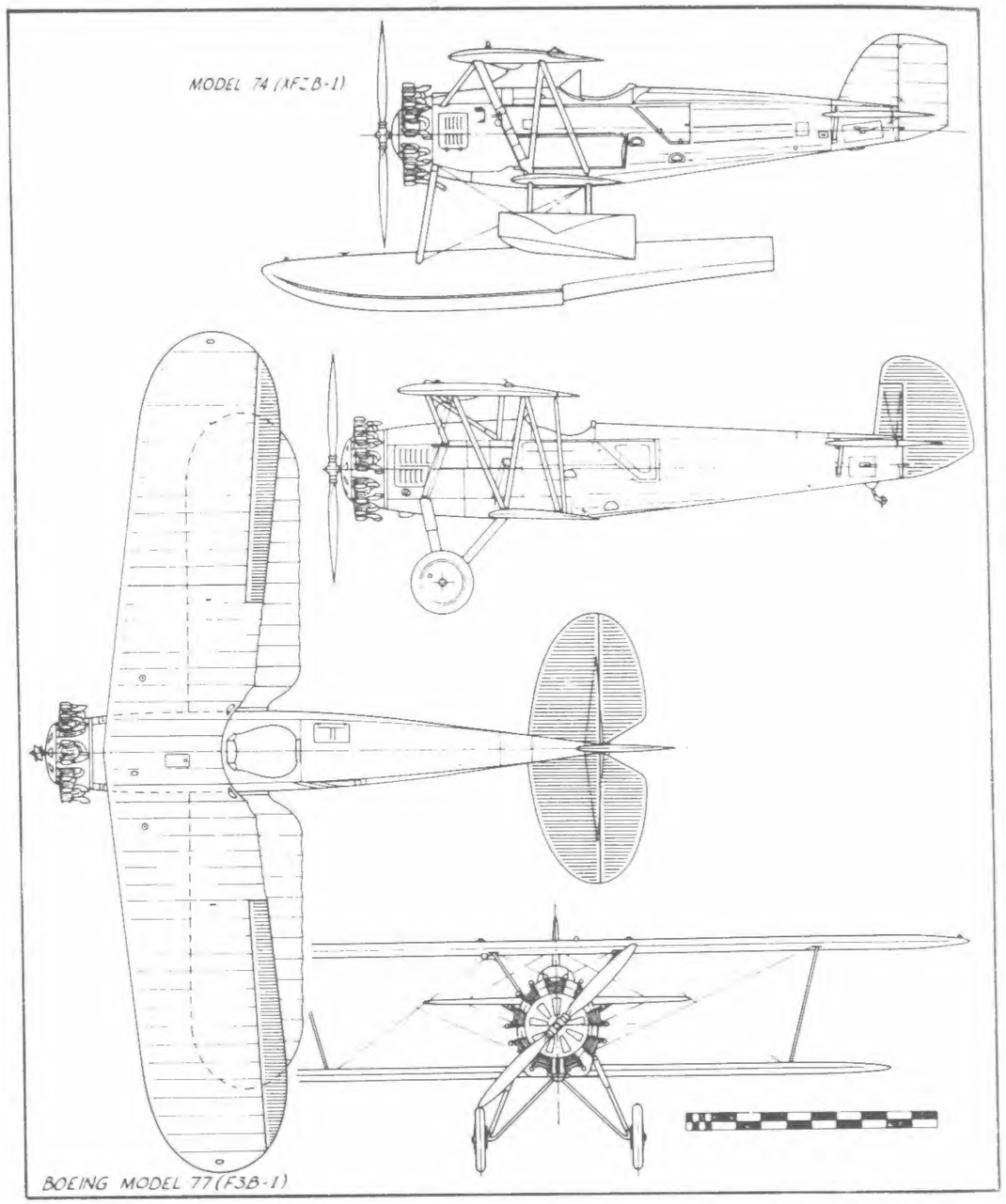
Type:	Shipboard or seaplane fighter
Accommodation:	1 pilot
Power plant:	P & W R-1340 Wasp 425 hp at 1,950 rpm
Span:	30 ft 1 in
Length:	22 ft 9 in (land) 27 ft 3½ in (sea)
Height:	9 ft 3 in (land) 10 ft 4 in (sea)
Wing area:	235 sq ft
Empty weight:	1,919 lb (land) 2,119 lb (sea)
Gross weight:	2,715 lb (land) 2,837 lb (sea)
Max speed:	156·7 mph (land) 154·8 mph (sea)
Cruising speed:	131 mph (land)
Climb:	2,020 ft/min (land) 1,770 ft/min (sea)
Range:	336 miles (land)
Armament:	Two ·30 cal MG, five 25 lb bombs
C/n:	878
Navy serial number:	7674 (as F3B-1)

The XF3B-1 was completely rebuilt as a new aeroplane, Boeing Model 77, and was sold to the Navy as the first aeroplane on the production F3B-1 order. Only the prototype in its two forms could be fitted as a seaplane. The corrugated metal rudder in the contour shown was peculiar to the rebuilt prototype. (*Photo by Arthur Price*)

Production F3B-1 in its later years. The Townend anti-drag ring around the engine, which was developed after F3Bs were delivered, was installed by the Navy. (*Bowers Collection*)

MODEL 77 (F3B-1) - After the Model 74 (XF3B-1) was returned to the factory, it re-emerged as almost an entirely different aeroplane. The fuselage and engine installation were essentially the same except that the nose was lengthened, but the undercarriage, wing, and tail were completely changed. The upper wing, while still a one-piece unit with built-up spars and jigsawed plywood ribs, featured constant chord and a sweepback angle of 6 deg 28 min. The lower wing was still two-piece, but with constant chord and no sweepback. The tail surfaces of the new prototype, now called F3B-1, retained the general outline of the XF3B-1, but in common with the ailerons, used an entirely new method of semi-monocoque all-metal construction in which stiffness was provided by the corrugated covering. This type of construction proved to be so satisfactory that it was retained for all subsequent production Boeing biplane fighters and the last experimental biplane fighter, the XF6B-1 of 1933. The cost of each production F3B-1, less GFE, was $11,470.

Streamlined wheel fairings, or 'pants', were not standard F3B-1 equipment. A few handmade sets were installed on some obsolescent service aircraft withdrawn from the fleet and used by high-ranking officers for their own transport and proficiency flying. This F3B-1 was based at the Anacostia Naval Air Station near Washington, D.C. (*Photo by William N Fleming*)



The fuselage of the production F3Bs reverted to an earlier type of construction in that the tubes aft of the cockpit were welded in place instead of being bolted. The undercarriage of the rebuilt prototype was of the oleo type similar to the F2B-1 with a dummy cross-axle or spreader bar to hold carrier deck guide hooks, but this feature was deleted from the production models soon after delivery. The principal outward difference between the production F3B and the rebuilt prototype was in the shape of the vertical tail and the prototype was flown on a single float as well as wheels.

The first flight of the rebuilt prototype in production form was February 3, 1928. The first production model was delivered on August 15 of the same year and the last of 73 (74 with prototype) was delivered on November 23.

Some were assigned to fighter squadrons and some to bomber squadrons on the aircraft carriers *Saratoga* and *Lexington*. Dual use of the aeroplanes did not alter the basic fighter designation. The use of the dual symbol BF to designate a bomber-fighter was not adopted by the Navy until March 1934. Eighteen F3Bs were returned to the factory for overhaul and were delivered to the carrier *Saratoga* in bomber configuration in December 1929.

TECHNICAL DATA - F3B-1

Type:	Shipboard fighter-bomber
Accommodation:	1 pilot
Power plant:	P & W R-1340 Wasp, 425 hp at 1,950 rpm
Span:	33 ft
Length:	24 ft 10 in
Height:	9 ft 2 in
Wing area:	275 sq ft
Empty weight:	2,179 lb
Gross weight:	2,945 lb
Max speed:	157 mph
Cruising speed:	131 mph
Climb:	2,020 ft/min
Service ceiling:	21,500 ft
Range:	340 miles
Armament:	as XF3B-1
C/ns:	938/1010
Navy serial numbers:	A-7675/7691, A-7708/7763

MODEL 93 (XP-7) - The XP-7 was the last aeroplane on the PW-9D order (28-41) and was retained at the factory for the experimental installation of a 600 hp water-cooled Curtiss Conqueror V-1570 engine, an enlarged and improved version of the 435 hp D-12 used in the standard

The XP-7 (Boeing Model 93) was the last PW-9D, modified to test the new 600 hp Curtiss Conqueror engine. The aeroplane was reconverted to a standard PW-9D upon completion of the testing. (*USAF Wright Field Photo 35503*)

PW-9. The XP-7 was delivered on September 4, 1928. The XP-8 preceded the XP-7, but its military designation was assigned later.

The engine proved to be suitable for use in fighters, and an Air Corps specification was drawn up to cover the building of four service test P-7s. However, in recognition of the facts that the PW-9 series had about reached the limit of its growth and that Boeing was developing a promising new fighter, the project was cancelled and the XP-7 was reconverted to a PW-9D by the Army. With the exception of the experimental XP-9, the PW-9D/XP-7 was the last Boeing fighter to use a liquid-cooled engine. Specifications as PW-9D except empty weight 2,358 lb, gross weight 7,260 lb, and high speed 167·5 mph.

C/n: 1026
Army serial number: 28-41

MODEL 202 (XP-15) - Production of the P-12s and F4Bs for the Army and Navy (Chapter 5) was barely under way when Boeing realized that the conventional biplane fighter was nearing the end of its growth potential and that changes would have to be made soon in the traditional fighter aircraft pattern that had prevailed throughout the world since 1916. Rather than start with a radically new design that broke sharply with tradition as had the XP-9 monoplane requested by the Army and the Model 200 Monomail, both of which were under construction at the time (Chapter 6), Boeing engineers decided to bring new concepts into the conservative military market slowly by cleaning up an already established design and offering it to both the Army and the Navy on speculation.

As first planned, the new design was merely the basic Model 89, second prototype of the F4B/P-12 series redesigned as a monoplane through deletion of the lower wing and the addition of struts to support the upper

The all-metal Boeing Model 202 of 1930 was tested by the Army as XP-15 but remained Boeing property. Many of its structural features were incorporated in later production models. (*Boeing Photo P-3411-B*)

wing, which was moved slightly aft to keep the centre of lift in the proper position relative to the centre of gravity. This design was known as Model 97, but was not built. Following a decision to go to all-metal construction with a new fuselage design based on the XP-9 (Model 96), the designation was changed to Model 202. The big jump from 92 to 202 resulted from the fact that the company had just set aside Model numbers 103 to 199 for the identification of Boeing-designed aerofoil sections.

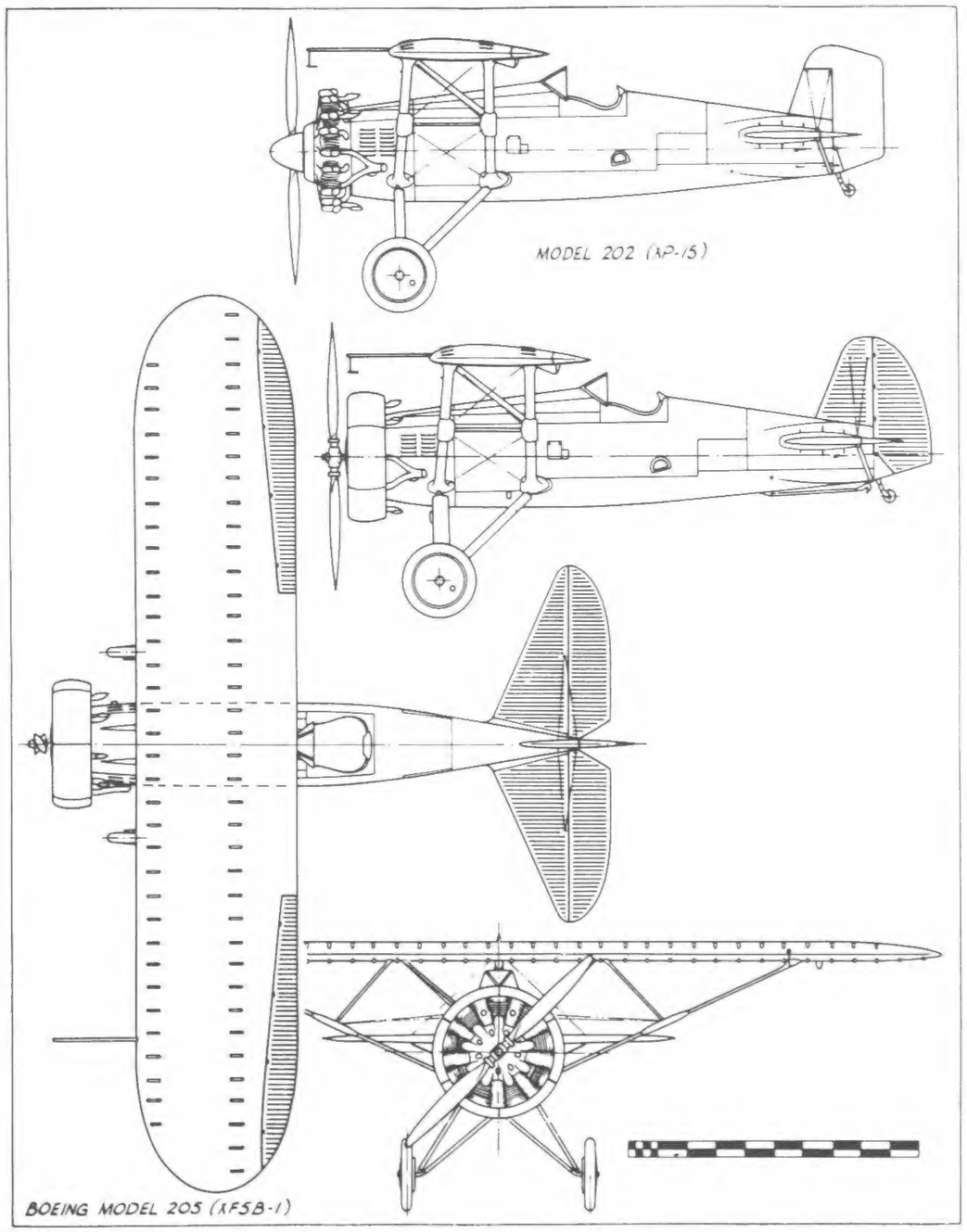
Since this was a company venture not supported by the military, the Model 202 carried the grey, orange and green Boeing colour scheme when it left the factory for its first flight in January 1930, and carried the civil registration of X-270V instead of military insignia. The military designation of XP-15 was assigned unofficially when the Air Corps accepted the 202 at Wright Field for flight-test on a bailment contract on March 10, 1930. Except for the absence of a lower wing, the XP-15 looked like a P-12B (Model 102B) with a smooth metal skin since the sizes and shapes of the major components were the same. The shape of the vertical tail was changed to that standard for the later Model 218 and a ring cowl similar to that tested on the Model 100 and installed on production P-12Cs was added before the XP-15 was sent to Wright Field.

The new fuselage structure was similar to that of the XP-9 in that the portion aft of the undercarriage rear attachment point was a semi-monocoque structure with dural formers, longitudinal stiffeners, and dural skin. The structure forward of this point was welded steel tubing covered with removable access panels and cowling. The tail surfaces differed from the all-metal type used on the XP-9 and the P-12/F4B/100 series in that the original metal skin was smooth instead of being corrugated, although the second fin-rudder combination was corrugated. External tail bracing was identical to that of the biplanes. The wing was similar to that of the upper P-12/F4B wing except for a 6 in increase in span, the substitution of built-up dural spars and ribs for wood, and the use of dural skin for covering. Internal drag bracing wires were eliminated from this wing structure

Boeing Model 205 was a near-duplicate of the 202 submitted to the Navy for test as a shipboard fighter and was eventually purchased as XF5B-1. 202 later got the same tail shape. (*US Navy Photo AN-7631*)

because the drag loads were taken by the metal skin.

Deletion of the lower wing increased the top speed of the XP-15 over that of the P-12B, but the rate of climb, the manoeuvrability, and the landing speed suffered from the decrease in area and the design was not accepted for production by the military. However, while the aerodynamic design was rejected, many of the structural features of the 202/XP-15 and its sister ship, the Model 205 tested by the Navy as XF5B-1, were incorporated in later models of the P-12/F4B series then in production.



After return to the factory from Wright Field, the XP-15 was used for further test and development work. It crashed on February 7, 1931, at the southwest edge of Seattle, when a propeller blade failed during a vertical climb following a high-speed run and the resulting vibration shook the engine out of the aeroplane.

MODEL 205 (XF5B-1) – Model 205 was a duplicate of the Model 202 and differed from it mainly in being fitted for operation from aircraft carriers as a fighter-bomber. These differences, resulting in a higher gross weight, were sufficient to justify a separate company model designation. The Model 205 was originally tested by the Navy on a bailment contract as Boeing property with civil registration X-271V and colour similar to the XP-15. Although rejected as a production type it was bought under a later purchase contract for $50,000, including engine and equipment, and the naval designation of XF5B-1 became official. Naval colouring and markings were applied following the purchase.

Outwardly, the XF5B-1 could be distinguished from the XP-15 only by the deck-hook installation. As originally built, the XF5B-1 had the same small-area smooth-skin vertical tail surfaces as the XP-15, but these were replaced by a new and larger corrugated type. The addition of the new tail and ring cowlings to both the XP-15 and the XF5B-1 again made them duplicates in outward appearance. General specifications and performance of the two models were practically identical, but the Model 205 was heavier, with a gross weight of 2,808 lb as a fighter and 3,419 lb as a bomber, due mainly to increased fuel (131 gal vs 83) and bombs. Sea-level speed of the 205 was higher, 171 mph, due to higher sea-level engine rating.

The XF5B-1 was delivered to the Navy on February 9, 1930, without having been test flown at the factory, the earlier test flights on the XP-15 having satisfied company officials that the duplicate should be equally airworthy. Following three years' use of the aeroplane for experimental purposes, the fuselage of the XF5B-1 was static tested at the Naval Aircraft Factory in October 1933, to determine the integrity of the all-metal structure and the wing was static tested to destruction in March 1936.

TECHNICAL DATA - XP-15/XF5B-1

Type:	Fighter
Accommodation:	1 pilot
Power plant:	P & W SR-1340D Wasp, 450 hp at 2,200 rpm at 8,000 ft (XP-15); P & W SR-1340C Wasp, 480 hp at sea level (XF5B-1)
Span:	30 ft 6 in
Length:	21 ft
Height:	9 ft 4 in
Wing area:	157·3 sq ft
Empty weight:	2,052 lb (XP-15) 2,062 lb (XF5B-1)
Gross weight:	2,746 lb (XP-15) 3,419 lb (XF5B-1)

	XP-15	*XF5B-1*
Max speed:	163 mph at sea level 190 mph at 8,000 ft	171 mph at sea level
Cruising speed:	160 mph at 8,000 ft	145 mph at 60% power
Climb:	1,800 ft/min at 8,000 ft	1,850 ft/min at sea level
Service ceiling:	26,550 ft	26,400 ft
Range:	421 miles	690 miles
Armament:	Two ·30 cal MG	One ·30 cal, one ·50 cal, or two ·30 cal MG. Five 30 lb bombs or one 500 lb bomb

C/ns	*Registrations*	*Navy serial number*
1151	X-270V (XP-15)	–
1152	X-271V (XF5B-1)	A-8640

MODEL 236 (XF6B-1, XBFB-1) – While the Boeing model number of 236 assigned to the Navy XF6B-1 was not the last assigned to a Boeing biplane fighter, that aeroplane was the last 'new' Boeing biplane design to be built except for Stearman (later Wichita Division) trainers built through the end of WW-II. The later factory designations were applied to improved models of the long-established P-12/F4B series (Chapter 5) and their export derivatives that were in production after Model Number 236 had been assigned to a new design initiated in 1931.

In addition to being the last Boeing biplane fighter design, the XF6B-1 was also the last fixed undercarriage biplane fighter submitted to the Navy by any manufacturer and clearly showed that this type had reached the peak of its development after monopolizing the fighter field for nearly two decades. Army procurement of biplane fighters ended with the fixed-undercarriage P-12Fs delivered in May 1932, but the Navy, recognizing the continued desirability of the slow-landing biplane for carrier work, carried refinement of the basic design a little further by encouraging the use of retractable undercarriages for conventional biplanes. This resulted in only a short extension to the life of the biplane fighter, however, the 1,000 hp Grumman F3F-3 of 1937 being the last of the type procured.

The XF6B-1 was a new shipboard fighter developed around the new 14-cylinder twin-row Pratt & Whitney Twin Wasp Jr engine of 625 hp, installation details for which had been worked out by tests of the engine in the Boeing 100F delivered to Pratt & Whitney in 1932. The general structure of the XF6B-1 followed that of the P-12E/F4B-3 except that the wing, although fabric-covered, was of all-metal construction. The ribs were built up of metal angle-strips and the spars were built-up dural boxes. Tie rods were retained for internal bracing and, as in the older designs, wire was used for the trailing edge.

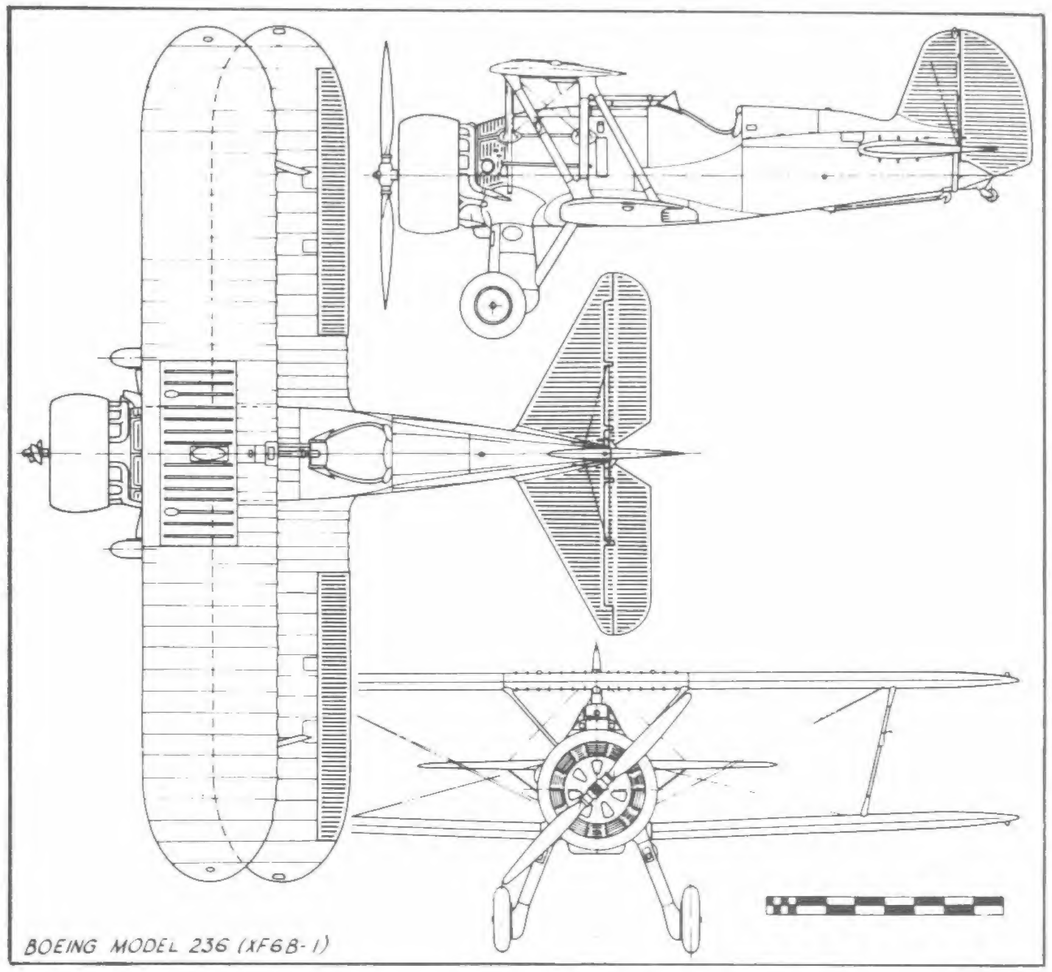
The greatest departure from previous practice was in the undercarriage. The rear struts of the XF6B-1 gear formed two rigid structures, and the wheel was carried on an arm that pivoted on the end of the rigid portion with the shock being absorbed by an oleo strut running from each wheel

The single XF6B-1 (Model 236) was the last biplane fighter design developed by Boeing and marked the end of a design era for the company. (*Boeing Photo P-6063-B*)

axle to a forward point on the fuselage. At first, this oleo was outside the fairing that streamlined the rigid unit, but the fairing was later expanded to cover each side of the entire gear, giving it the appearance of a large single-strut unit.

The XF6B-1 first flew on February 1, 1933, and after several minor changes of cowling and other details, including trial of a three-blade propeller, was delivered to the Navy on April 23, 1933. While not accepted for production, the XF6B-1 was used for test work at Anacostia and at the NACA facility at Langley Field, Virginia. The Navy changed the classification of the aeroplane from fighter to bomber-fighter on March 21,

The Navy gave the XF6B-1 the dual-purpose designation of XBFB-1 in March 1934, to identify it as a fighter-bomber. Compare revised landing gear and controllable-pitch propeller to earlier XF6B-1 configuration. (*Photo by Richard H Lober*)



1934, and assigned the designation of XBFB-1 to it at that time. Total cost of the XF6B-1/XBFB-1 by the end of the programme was $82,305.

TECHNICAL DATA - XF6B-1

Type:	Fighter-bomber
Accommodation:	1 pilot
Power plant:	P & W R-1535 Twin Wasp Jr, 625 hp at 2,100 rpm at 5,500 ft
Span:	28 ft 6 in
Length:	22 ft 1½ in
Height:	10 ft 7 in
Wing area:	252 sq ft
Empty weight:	2,288 lb
Gross weight:	3,704 lb, 4,283 lb (bomber)
Max speed:	200 mph (fighter) 185 mph (bomber)
Cruising speed:	170 mph
Service ceiling:	24,400 ft (fighter) 21,100 ft (bomber)
Range:	525 miles
Armament:	Two ·30 cal MG, one 500 lb bomb, two 115 lb bombs
C/n:	1625
Navy serial number:	A-8975

Chapter 4

EARLY NAVY AND COMMERCIAL DEVELOPMENTS

With the company thoroughly re-established in the aircraft manufacturing business as a result of the MB-3 order and the de Havilland rebuilding and modification programme, it became possible to devote increased attention to the design and the development of new Boeing aeroplanes for a market that was beginning to recover from the stagnation of the immediate postwar years. The first of these, the XPW-9, has been described in detail in the previous chapter together with the large family of single-seat fighters that trace their origins directly to it.

Other new Boeing designs soon appeared in a variety of fields for both naval and commercial use and are described in this single chapter because they were developed over a relatively short period of time, 1923 to 1929, and generally reflect the contemporary structural and aerodynamic design concepts of a period that was still dominated by the requirements established during WW-I. Boeing, as well as other manufacturers, had done research along newer lines, but had been unsuccessful in finding a market for aeroplanes designed to more advanced concepts. 'New' designs that were

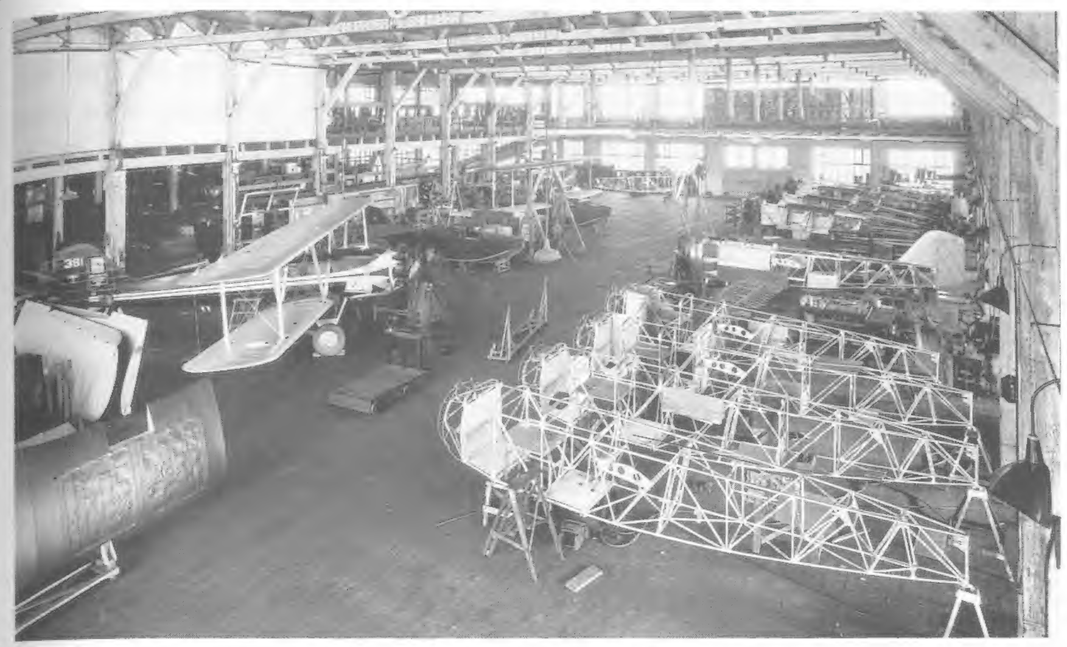
The Boeing plant in December, 1928. A few of the original Heath Shipyard buildings can be seen behind the large assembly building at the water's edge. This complex became Plant 1 upon erection of a new assembly building on Boeing Field in 1936. (*Boeing Photo P-2209-B*)

anything other than a minor refinement of the basic aeroplane configurations developed during WW-I were not acceptable to a highly conservative market that still thought in terms of the war. This attitude naturally had a great effect on the industry and resulted in fundamental changes being introduced very slowly. Boeing, a conservative organization both from the standpoint of policy and engineering, found it easy to accept the market requirements and design basically traditional aeroplanes. While some unorthodox designs were considered on paper, nothing of that nature came out of the shop.

Progress during these conservative postwar years was made through refinement of established design rather than by daring innovation. The degree to which Boeing was able to match the thinking of the market, mainly the United States Government, is reflected in the size and frequency of the orders placed with the company during this period. In practically every case where orders for similar types of aircraft were placed simultaneously with other companies according to prevailing government policy, the Boeing order was the largest.

A very significant move was made early in 1927. The Post Office asked for bids from private industry for operation of the transcontinental airmail service that had been operated up to that time by the government. Boeing had developed a mail-carrying aeroplane to Post Office specification in 1925, but it had the major disadvantage of being powered with the heavy water-cooled war surplus Liberty engine. The more efficient air-cooled radial had appeared in the early 1920s, but with only 200 hp it had not reached the point where it could, at the time the mailplane was designed, compete with the 420 hp Liberty. Not until Pratt & Whitney developed the 425 hp Wasp in 1926 did a suitable commercial replacement for the Liberty become available.

One of the first Wasps had been installed by the Navy in the Boeing FB-6, and Boeing had immediately set to work to develop a new fighter model specifically for it. Following tests of the Model 69, or XF2B-1, the Navy placed a production order for 32 aircraft. Realizing that the far more reliable Wasp weighed 200 lb less than the Liberty, exclusive of water, radiator, and plumbing, which allowed correspondingly greater payload for the same aeroplane, Boeing officials decided to redesign the 1925 Model 40 to take the new engine and make a bid for the mail route. Unfortunately, all Wasp production had been committed to the US Navy and none would be available for commercial use for a year. Mr Boeing was able, through his friendship with Frederick B Renschler, president of Pratt & Whitney, to arrange for the Navy to release to him the Navy engines then being built for the F2B-1s on assurance from Renschler that replacements would be available when needed for installation in the fighters. With the engine supply problem solved, Boeing sought the San Francisco to Chicago portion of the route, basing its bid on the increased carrying capacity of the new Model 40-A, which could also add passenger revenue to mail payments. Competing bids, based on aeroplanes still using the heavy Liberty and



Mixed models under construction in Plant 1 in December 1928. At left, Model 40Y and two Model 204s; at right, Models 95 and 40B-4. (*Boeing Photo 2223-B*)

carrying no passengers, were nearly twice as high, and the Boeing Airplane Company was awarded the route. The industry at large expected the new line to fail in short order, but it prospered from the first. When asked how this was possible, Mr Boeing, indirectly quoting the advantage that the Wasp had over the Liberty, commented that he was carrying payload instead of radiators and water over the mountains.

Acceptance of its airline bid began an entirely new era for the Boeing Airplane Company. A new company, Boeing Air Transport, was formed to operate the airline. While it was a separate corporation, Boeing Airplane executives comprised the management. Initial operation was with Boeing aeroplanes exclusively, the Model 40-As. The insignia of the new airline was derived from the winged Boeing trademark, which spelled the word BOEING. The words AIR TRANSPORT, INC. were added to a double circle around the trademark. The original routes were expanded late in 1928 by the acquisition of Pacific Air Transport (PAT), a San Francisco to Seattle airline. The combined lines became known as THE BOEING SYSTEM, and a revision was made to the established trademark. On the former PAT route, the words AIR TRANSPORT, INC. were removed from the circle and replaced by the single word SYSTEM, while the words PACIFIC AIR TRANSPORT were painted on a straight line flanking the trademark. The original trademark was retained for the Boeing Air Transport routes. Under Boeing ownership, PAT bought Boeing equipment but continued to operate some of its original equipment as well.

Company activity increased in other directions, too. In February 1929, Boeing acquired the Hamilton Metalplane Company of Milwaukee, Wisconsin, which became a subsidiary of Boeing while continuing to manufacture aeroplanes of its own design under its own name. In the

summer of 1929, Boeing and the Hoffar-Breeching Shipyard of Vancouver, Canada, a large yacht-building firm, formed Boeing Aircraft of Canada, Ltd, to manufacture Seattle-designed aeroplanes in Canada. The first products were Model 204 flying-boats, called C-204s to designate them as Canadian-built.

The most significant move of the period, however, was the formation of United Aircraft and Transport Corporation, with the headquarters in Hartford, Connecticut. It was a holding company owning all of the capital stock of the Boeing Airplane Company and its Hamilton subsidiary, Boeing Air Transport, Inc and its subsidiary PAT, the Chance Vought Corporation, a manufacturer of Navy fighter-observation aircraft, Hamilton Aero Manufacturing Company, a propeller manufacturer, and the Pratt & Whitney Aircraft Company, the well-known engine manufacturer. Each company remained in business under its own name with its own product line that complemented, rather than competed with, the products of the other member companies. This association was to have a great effect upon subsequent Boeing activity, and resulted in the standardization of Pratt & Whitney engines and Hamilton (later Hamilton-Standard) propellers on most subsequent Boeing aeroplanes unless others were specifically required by the customer. Having two aeroplane manufacturers in the corporation was compatible as their product lines were not competitive.

Both the airline and manufacturing sides of United grew rapidly. Sikorsky Aviation Corporation, a New England manufacturer of amphibians, was added, followed by the Stearman Aircraft Company of

In 1929, passenger accommodation was spartan and loading procedures were simple, as demonstrated with a Varney Air Lines Boeing 40B-4. (*Boeing Photo*)

Fokker F-10A trimotors continued to operate over Pacific Air Transport routes after that line had been absorbed int the Boeing System. PAT routes were not competitive with those flown by Boeing Model 80 trimotor biplanes. (*Boeing Photo*)

Wichita, Kansas, and the Standard Steel Propeller Company. Stout Airlines, covering the route from Chicago to Cleveland, was added to the Boeing/PAT routes, and was soon followed by National Air Transport (NAT) with routes from Dallas, Texas, to New York City by way of Chicago. The final airline acquisition was Varney Air Lines, which ran from Reno, Nevada, to Pasco, Washington, via Boise, Idaho. As a result of the increased airline activity, a new management company known as United Air Lines, Inc., was formed to operate the lines, which like the manufacturing companies continued to function under their original names. The airline insignia was again modified. The original Boeing Bug was retained, with the original name of each member airline painted inside the double circle and the words UNITED AIR LINES flanking the circle and backed by a white rectangle. In addition to the offices he held in Boeing Airplane Company and Boeing Air Transport, William E Boeing became chairman of the board of United Aircraft and Transport Corp, with F B Renschler as president.

The formation of such huge corporations as United was proof that aviation and air transport had become big business in the late 1920s. Trouble was ahead, however, in the form of the world-wide economic depression that followed the stock market crash of 1929, and resulted in serious curtailment of economic support for aeronautical activity both civil and military and in government investigation of big business. United became a prime target of the trust-busters, as the government investigators were called, and was eventually forced to divorce the manufacturing and operating organizations under new laws, including the Air Mail Act of 1934, which forbade aircraft or engine manufacturers to have interests in airlines. Pratt & Whitney, Vought, Sikorsky, and the now-merged Hamilton Standard Propeller Company became a new United Aircraft Corporation, while the airlines, National Air Transport, Boeing Air Transport, Pacific Air Transport, Varney, and BAT's subsidiary, the Boeing School of Aeronautics, became United Air Lines Transport Corporation. This

Obsolete Boeing 40B-2 converted to dual-control instrument trainer shown on flight line at Boeing School of Aeronautics with three Boeing 203As and a 203B, October 1939. (*Photo by Boardman C Reed*)

resulted in still another change to the airline insignia. The original names and the Boeing trademark were removed from the circle and replaced by a silhouette map of the United States, showing United's routes, while the words UNITED AIR LINES were retained in the rectangles flanking the circle.

The Boeing Airplane Company, with Stearman as a subsidary, again became an independent organization and Mr Boeing took his leave of the company that he had founded eighteen years before.

MODEL 21 (VNB-1, NB-1/4) – The next original Boeing design to be built following the Model 15 fighter was the Model 21, prototype of the production primary trainer models that were designated NB-1 and NB-2 by the US Navy. The designation of VNB-1 applied to the prototype was not entirely correct. The letter N correctly identified the design as a Navy trainer, but while the letter V designated Navy heavier-than-air aircraft types, it was not used as part of the actual aircraft designation.

The Model 21 incorporated such advanced features for the period as N-struts to eliminate the wing incidence wires, divided-axle undercarriage

US Navy NB-1 primary trainer (Boeing Model 21). Note post-production addition of external pitot-static lines for airspeed indicator on leading edge of lower port wing. (*USMC Photo 517552*)

with elastic cord shock absorbers, and the new 200 hp Lawrance J-1 air-cooled radial engine. The only unconventional feature was the use of a wide centre section for both wings, braced by an additional bay of struts, and the fact that the upper and lower wing panels could be interchanged. The aerofoil was the then uncommonly thick Göttengen 387, again reflecting Fokker influence, while the general structure was based on that of the Model 15. Provision was made for operating the Model 21 as either a land or a seaplane.

The first Model 21 was tested extensively by the Navy but was rejected at first as a primary trainer because it was almost too easy to fly and could not be spun. Modifications were made which allowed the aircraft to spin, and production orders resulted. Five additional Model 21s were built and delivered to the government of Peru, three in 1924 and two in 1927.

TECHNICAL DATA – MODEL 21 (VNB-1)

Type:	Primary trainer
Accommodation:	2 crew in tandem
Power plant:	Lawrance J-1 200 hp
Span:	36 ft 10 in
Length:	28 ft 9 in (seaplane)
Wing area:	344 sq ft
Empty weight:	2,136 lb
Gross weight:	2,837 lb
Max speed:	99·5 mph
Cruising speed:	90 mph
Service ceiling:	10,200 ft
Range:	300 miles
C/ns:	518; 649/651, 936, 937 (Peru)
Navy serial number:	A-6749 (518)

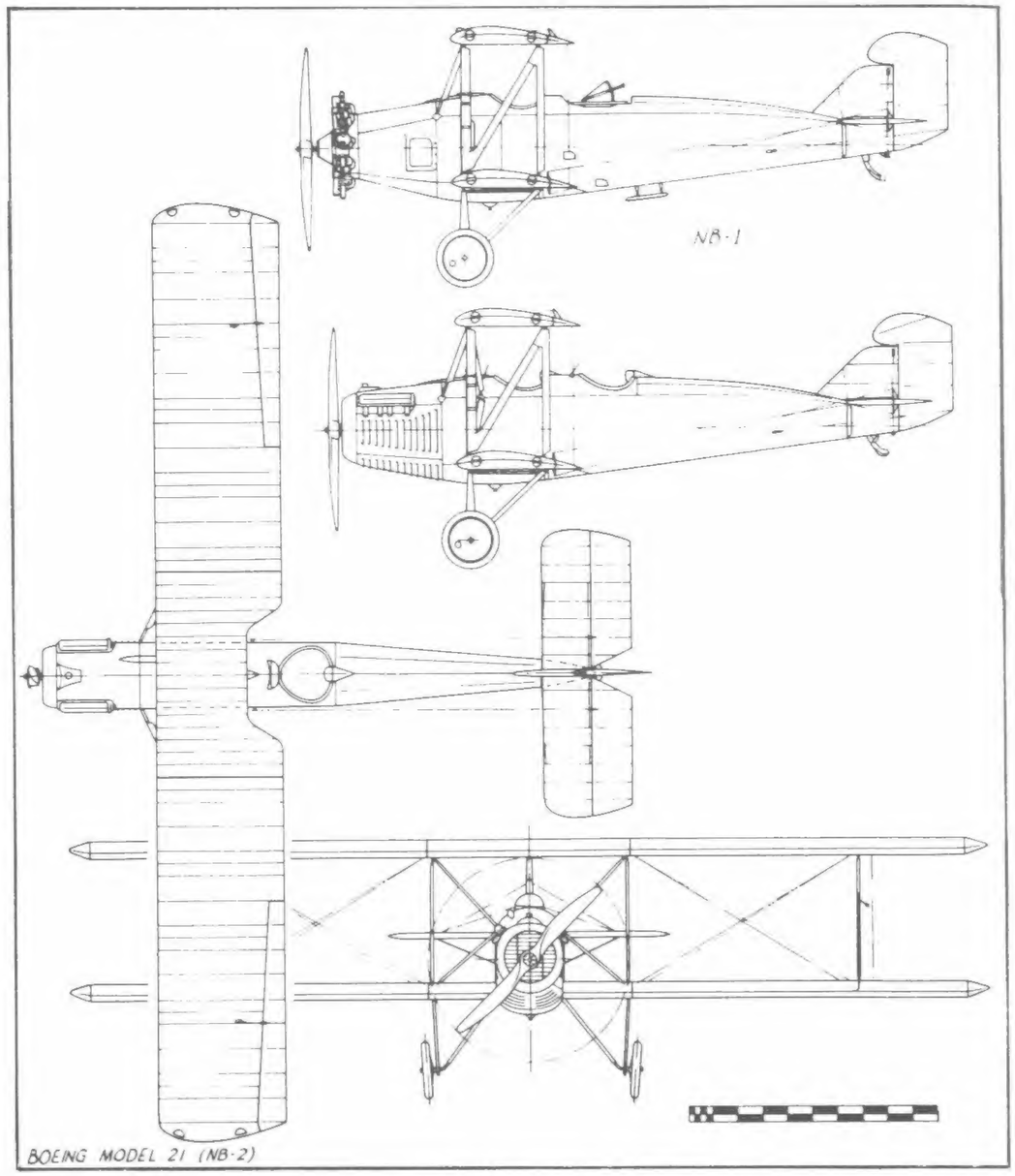
• NB-1 – Forty-one production NB-1s were delivered to the Navy, starting on December 5, 1924. The modifications incorporated to permit spinning as required by the training curriculum proved disadvantageous in that the aeroplanes became too spinnable and went into flat spins from which they could not recover. Compromise modifications were worked out to make the design acceptable. Average unit price of the NB-1 was $7,265, less power plant and government furnished equipment (GFE). The apparent discrepancy of a Lawrance J-1 engine in the prototype VNB-1 and Wright J-1s and later versions in the production NB-1s is because Wright absorbed the Lawrance company and continued production of the same engines under the Wright name. The J-1 engines cost $8,200 at first, but eventually came down to $5,900.

The thick wings of the NB-1 gave it good load-carrying characteristics. These were put to good use by the US Marine Corps, which modified some NB-1s for use as spray aircraft for mosquito control in the tropics after aerial spraying was found to be the most efficient way to handle the

problem. In their final years of service, Wright J-5 engines replaced the J-1s, 2s, and 4s in the NB-1s. One NB-1 was used by the Navy to test a new oleo-pneumatic shock absorbing undercarriage in April 1925.

The dimensions and performance of the NB-1 were identical to those of the VNB-1.

C/ns: 671/689, 753/774
Navy serial numbers: A-6750/6768, A-6836/6857



• NB-2 – The thirty NB-2s were structurally identical to the NB-1 except for the power plant, which was a war-surplus Wright-Hispano E-4 of 180 hp. Installation of this unit was made at the request of the Navy to take advantage of the large stocks of this French-designed but American-built powerplant that were still on hand.

NB-2 floatplane, differing from NB-1 mainly in engine installation. Note use of balanced elevators on this particular machine. (*Al Thometz Collection*)

Dimensions and performance as Model NB-1 except:

Empty weight: 2,336 lb
Gross weight: 3,037 lb

C/ns: 690/719
Navy serial numbers: A-6769/6798

• NB-3 – As part of the programme intended to overcome the undesirable spinning characteristics that had appeared in the NB-1s and 2s, Boeing retained the last two NB-1 airframes at the factory and fitted them with new lengthened fuselages fitted with various tail surface modifications. The first of the two modified aeroplanes, A-6856, was fitted with the Wright-Hispano engine of an NB-2 and was redesignated NB-3. The engine was moved 16 in forward and the tail was extended 26 in. The tail modification resulted in a distinctive downward bend in the upper longeron. The NB-3 was tested at the Sand Point Naval Air Station, both on wheels and floats, starting on June 27, 1925. However, the benefits of the modification were insufficient to justify the cost of reworking all the existing aircraft, so the NB-3 was refitted with a standard fuselage and power plant and delivered as an NB-1.

The single NB-3 was the next-to-last NB-1 fitted temporarily with a new longer fuselage and the Hisso engine of the NB-2 in an attempt to overcome the undesirable spin characteristics of the Model 21 design. (*Boeing Photo P-913-B*)

The NB-4 was the last NB-1 with a special long fuselage similar to that of the NB-3. Both the NB-3 and the NB-4 were reconverted to standard NB-1s. (*Boeing Photo P-940-B*)

• NB-4 – The second spin-test NB-1, A-6857, incorporated the same modification as the NB-3 except that it was fitted with the lighter Lawrance engine, which was moved forward 26 in. Testing began on July 9, 1925, but again the aeroplane was reconverted to standard configuration and delivered as an NB-1.

MODEL 40 – Although built to a Government specification, the Model 40 was the first purely non-military Boeing design since the BB-L6 of 1920 (Model 8). The Post Office Department had issued a specification for a Liberty-powered biplane to replace the de Havilland 4s then in use. The Model 40 was designed in April 1925, as Boeing's entry in the competition, and the first flew on July 7, 1925. The Post Office bought the single aeroplane but did not place a production order, so nothing further was done with the design at the time.

The wings and horizontal tail were of conventional wood construction, but the fuselage was rather unorthodox. Steel tubing was used in the nose and centre section areas, and for the structure from the rudder post to a point several feet forward of the leading edge of the tailplane. The mid-portion of the fuselage was built up of wood veneer over laminated wood

Original configuration of Liberty-powered Model 40 mailplane, July 3, 1925 (*Boeing Photo P-931-B*)

formers. The steel tube longerons of the forward and aft sections were attached to the longerons in the wood section through bolted splice plates but the wood veneer skin of the mid-section covered most of the surface of the steel tube areas.

The outline of the Model 40 was quite conventional except for the arrangement of the inner and centre section struts, quite similar to those of the NB but without the separate centre section. One most unusual feature was the unequal size of the two upper wing panels. The right wing fastened to cabane struts above the fuselage, but projected slightly to the left of the centreline to the point where the left wing joined the right. This offset location of the wing break is clearly shown in the Model 40B drawing.

TECHNICAL DATA - MODEL 40

Type:	Mailplane
Accommodation:	1 pilot, 1,000 lb mail
Power plant:	Liberty 400 hp
Span:	44 ft 2¼ in
Length:	33 ft 2¼ in
Height:	12 ft 3⅛ in
Wing area:	547 sq ft
Empty weight:	3,425 lb
Gross weight:	5,495 lb
Max speed:	135 mph
Service ceiling:	15,800 ft
Range:	700 miles
C/n:	775

• 40A – Early in 1927, when Boeing decided to bid on the San Francisco–Chicago portion of the transcontinental airmail route that the Post Office Department sought to turn over to private industry, the basic Model 40 was redesigned and modernized to give the company suitable equipment.

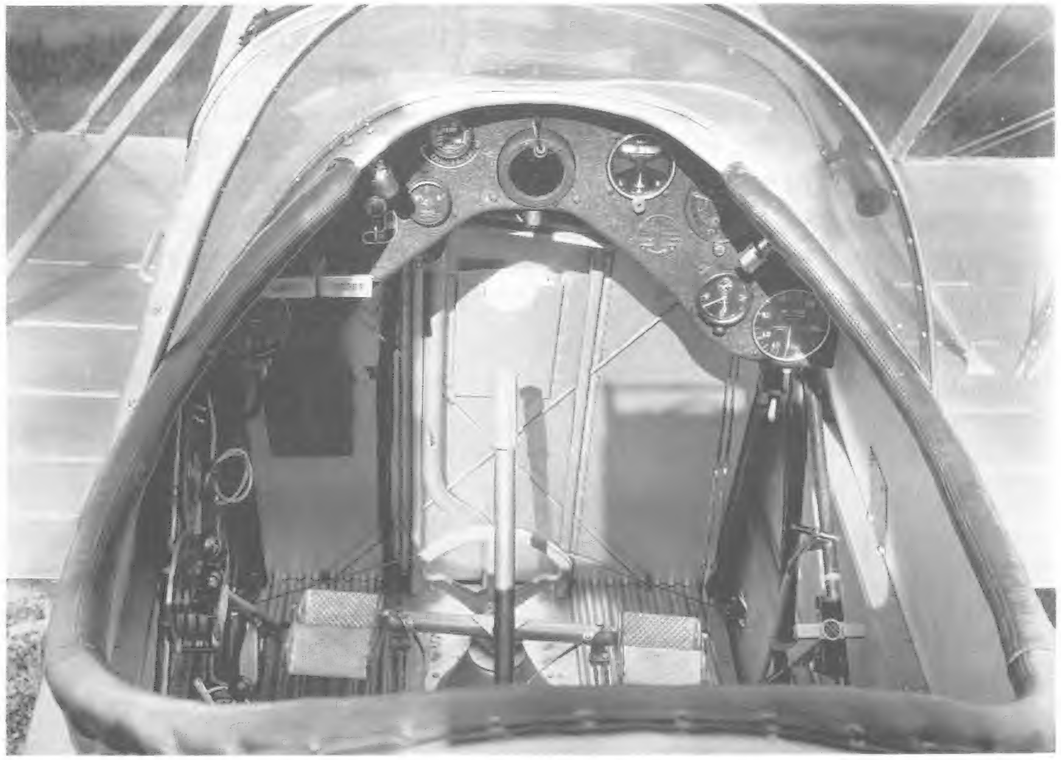
Two major advantages resulted from the new design. First, the new air-

Modified Model 40 with steel tube extension added to rear fuselage. (*Photo by Arthur E Price*)

cooled Pratt & Whitney Wasp radial engine gave the 40A a payload and performance increase over the generally-similar Douglas M-series and the Curtiss Carrier Pigeon biplanes then in use by competitive lines. Second, while the bid was submitted for an airmail route, additional income would be earned by carrying passengers in a two-seat cabin that was located between the pilot's traditional open cockpit and the mail compartment. One other major change distinguished the 40A from the original Model 40 – the fuselage structure was redesigned to use welded steel tubing throughout.

Based on the expected operating cost of the 40A, the Boeing bid was the lowest submitted and was awarded the route. Work began immediately on 25 40As, 24 for the new Boeing Air Transport Corporation and one for Pratt & Whitney as a flying engine test bed. The first 40A flew on May 20, 1927, and all were delivered to the airline by June 29, just in time for the inauguration of service on July 1. All were assembled for flyaway delivery at the Sand Point Naval Air Station north of Seattle because Seattle did not have a suitable airport close to the factory at the time.

Civil aviation in the United States had been unregulated in 1926, but starting in January 1927, strict control of aircraft airworthiness and registration was exercised by the Department of Commerce. The Boeing 40A was one of the first purely commercial designs to appear following adoption of the new regulations, and after testing it was issued Approved Type Certificate (ATC) No. 2, indicating that it met the full requirements of its particular category and could be issued an unrestricted licence.



Pilot's cockpit of a Model 40A with stick and rudder bar controls. Note lights mounted on cockpit coaming to illuminate the instrument panel for night flying. (*Boeing Photo 1524-B*)

The third Model 40A with registration number C270 misapplied as 3270. Airline emblem on fuselage carries the words AIR TRANSPORT INC in circle around the winged Boeing trademark. (*Boeing Photo P-1612-B*)

A technical oddity occured during the application of the new licence, or registration, numbers to these aeroplanes. While the assigned numbers were C-268 to C-292, someone mistook C for the figure 3 while listening to verbal instructions and painted the numbers accordingly. The error was soon corrected. The colour scheme of the 40As at the time of their manufacture was silver overall except for International orange on the upper surface of the upper wing.

TECHNICAL DATA - MODEL 40A

Type:	Mail and passenger biplane
Accommodation:	2 passengers, 1 pilot, 1,200 lb mail
Power plant:	P & W Wasp 420 hp
Span:	44 ft 2¼ in
Length:	33 ft 2¼ in
Height:	12 ft 3⅛ in
Wing area:	547 sq ft
Empty weight:	3,531 lb
Gross weight:	6,000 lb
Max speed:	128 mph
Cruising speed:	105 mph
Climb:	770 ft/min
Service ceiling:	14,500 ft
Range:	650 miles
C/ns:	879/903
Registrations:	C-268/292. C-270 to NC-270H, C-271 to NC-7471

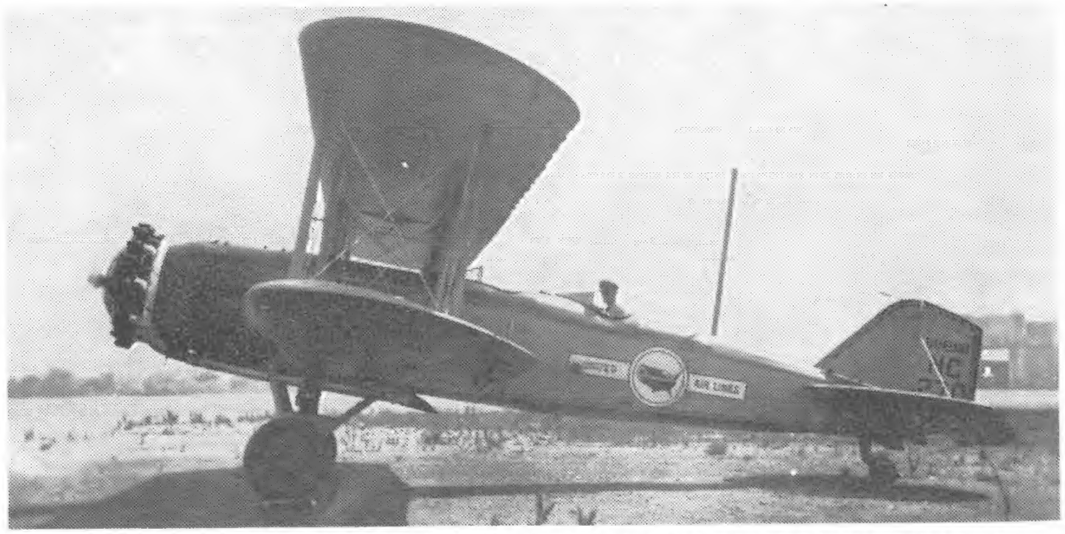
• 40B – No 40Bs were built as such, the designation being applied to 40s which had undergone replacement of the original 420 hp P & W Wasp engines with the larger 525 hp P & W Hornet. The increased power altered the characteristics and performance of the aeroplane sufficiently to require

Third Model 40A after conversion to 40B by change to larger P & W Hornet engine. Tail number corrected and aeroplane used temporarily for evaluation of refined fuselage contours. (*Boeing Photo P-2444-B*)

structural analysis and retesting for a new type certificate, No. 27, which was awarded on February 25, 1928. Two machines were later modified and removed from the ATC covering the standard 40B. These were serial numbers 882 and 1095 (the latter being designated 40Y) converted to two-cockpit dual-control models under Memo 2-30. Later modifications to an unspecified number of 40Bs following their retirement from mail/passenger service resulted in special-purpose licensing under Memo 2-64. A single special 40B conversion was later licensed under Memo 2-398.

Dimensions and performance as Model 40A except:

Empty weight:	3,542 lb
Gross weight:	6,079 lb



The Model 40Bs were redesignated 40B-2 to distinguish them from the later four-seat 40B-4s. NC-270 is shown here following conversion to a two-cockpit trainer with tall ratio antenna mast and the new United Air Lines insignia of 1934. (*E M Sommerich Collection*)

Grey-fuselage Boeing 40B-4 of Pacific Air Transport operating as a unit of United Air Lines. The name PACIFIC AIR TRANSPORT is carried in the circle around the trademark of the parent Boeing Air Transport System. (*Boeing Photo 4616*)

Max speed:	132 mph
Climb:	800 ft/min
Service ceiling:	15,000 ft
Range:	550 miles

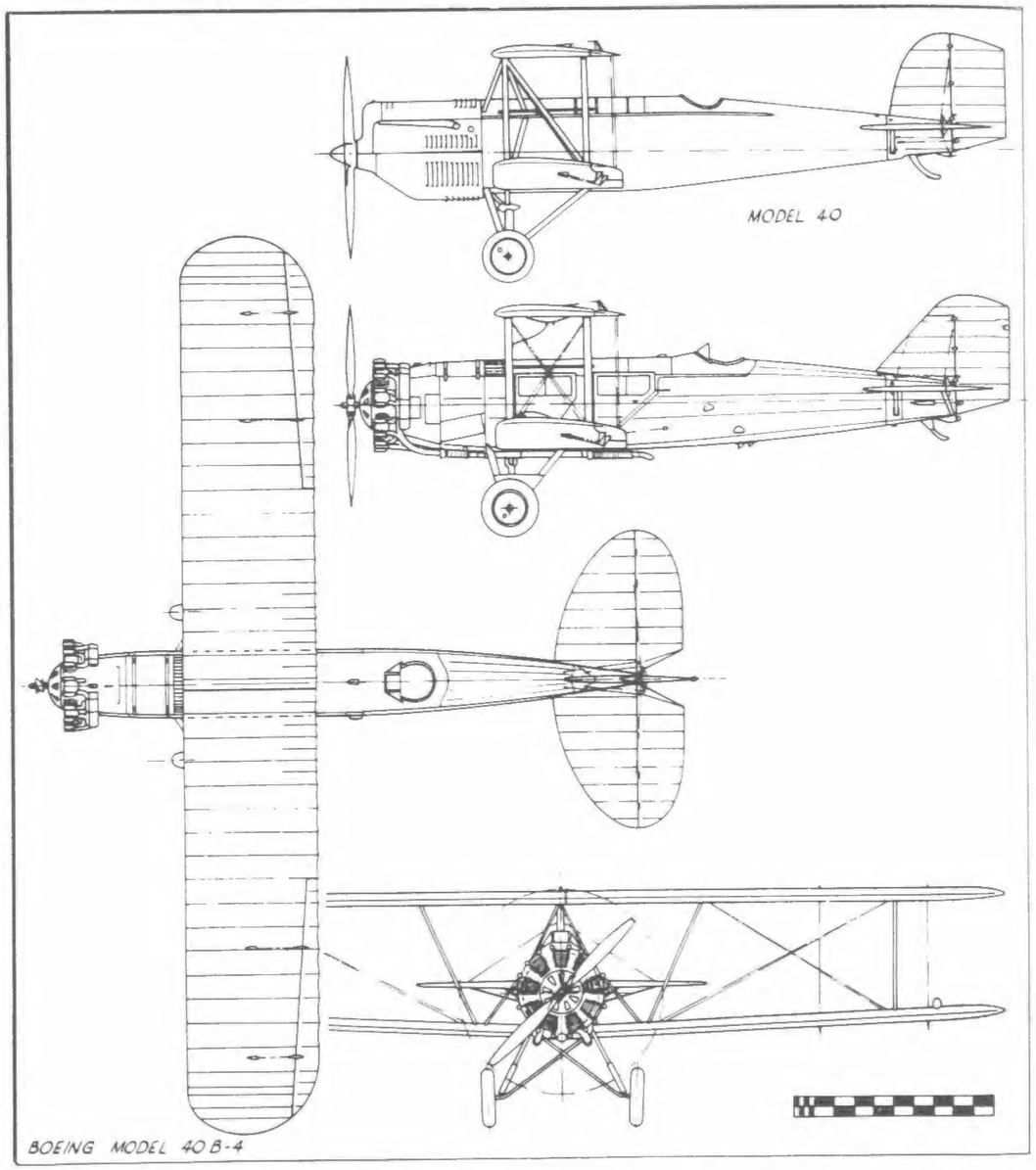
• 40B-2 – This designation was applied retroactively to the two-passenger Model 40Bs that were converted from the 40As in order to distinguish them from the later four-passenger 40B-4s that were built under that designation. Advertised price was $24,500.

• 40B-4 – This was a production version of the Hornet-powered 40B conversion with the cabin seating increased to four, like that of the earlier Model C, and a new balanced rudder. Many less apparent modifications were also incorporated, such as tailwheel, opening windows, electrical bonding and shielding for radio installation, and adjustable rudder pedals. The 40B-4 carried still another ATC, No. 183, issued on July 26, 1929.

While all but one of the 40As had been built for Boeing Air Transport, 40B-4s were sold to other lines that had been absorbed into the Boeing system while retaining their original names, and to private corporations and other independent airlines. The BAT models left the factory in the new

The single Model 40B-4A, a special flying test bed for Pratt & Whitney. The lower gear ratio of the experimental Hornet engine required a large-diameter three-blade propeller. (*Boeing Photo P-2603-B*)

standardized airline colours – French grey with Boeing green trim on fuselage and tail surfaces and International orange on the upper surface of the upper wing. Fuselages were later changed to all green, and orange was added under the bottom wing.



The 40B-4 first flew on October 5, 1928, and remained in production until February 1932. Following the sale of three to Western Canada Airways, five duplicates were built in the shops of Boeing-Canada in Vancouver, B.C., under the designation of 40H-4.

Two 40B-4s exist at the time of this writing, one in the Ford Museum at Dearborn, Michigan, and one in the Rosenwald Museum in Chicago.

TECHNICAL DATA – MODEL 40B-4

Type:	Mail-passenger
Accommodation:	4 passengers, 1 pilot, 500 lb mail
Power plant:	P & W Hornet 525 hp
Empty weight:	3,722 lb
Gross weight:	6,075 lb
Max speed:	137 mph
Cruising speed:	125 mph
Climb:	800 ft/min
Service ceiling:	16,100 ft
Range:	535 miles
C/ns:	1146/1150, 1155/1163, 1165, 1166, 1168, 1169, 1419/1438
Registrations:	C-278K, C-740K/743K, NC-830M/837M, CF-AIM/CF-AIO, NC-842M/843M, NC-10338/NC-10357

• 40B-4A – This was a standard production line 40B-4 delivered to Pratt & Whitney as a flying engine test bed on October 7, 1929, and incorporated sufficient changes to justify a separate designation. Initial power plant was the enlarged R-1860 geared Pratt & Whitney Hornet of 650 hp, driving a large area 10 ft 10 in three-blade propeller in place of the regular 10 ft 6 in two-blader.

The 40B-4A was painted to Pratt & Whitney specifications and did not carry the standard colouring of the other 40B-4s.

Dimensions and performance as Model 40B-4 except:

Empty weight:	3,722 lb
Gross weight:	6,075 lb
Climb:	1,070 ft/min
C/n:	1164
Registration:	X-813M

• 40C – Although carrying a later designation than the 40B-4, the 40C was an earlier aeroplane. It used the Wasp engine of the 40A and was essentially a four-passenger version of it built under ATC No. 54.

The Wasp-powered Model 40C was identical to the 40A except for the enlargement of the cabin to carry four passengers. (*Boeing Photo P-1969-B*)

The principal external recognition features were the extra cabin windows and the unbalanced 40A rudder. The first 40C flew on August 16, 1928, and the last of nine for Pacific Air Transport and one for National Parks Airways was delivered in December 1929.

All of the 40Cs were eventually converted to 40B-4 except PAT's C-6841 (Serial No. 1041) which was converted to a two-cockpit dual-control trainer for the Boeing School of Aeronautics in August 1929. The cost of a standard 40C at the time of manufacture was $23,500.

Dimensions and performance as Model 40A except:

Empty weight:	3,522 lb
Gross weight:	6,075 lb
Max speed:	125 mph
Cruising speed:	105 mph
Climb:	720 ft/min
Service ceiling:	14,500 ft
Range:	575 miles
C/ns:	1036, 1041/1044, 1096/1099, 1167
Registrations:	C-5340, C-6841, C-5389, C-5339, C-5390, C-178E/ C-181E, 841M

• 40H-4 – Four standard 40B-4s were built by Boeing-Canada with only a slight change of designation and serial numbers to indicate their Canadian origin. A fifth was registered but not completed. The letter H did not indicate any technical change from the Seattle-designed model but was used to honour Henry S Hoffar, president of the Canadian company. These were built for Canadian and export use and did not carry American ATCs. Two were sold to New Zealand and later re-sold to Austrialia: CF-AMR to ZK-ADY, to VH-ACL; CF-AMS to ZK-ADX, to VH-ADX. VH-ACL lost to Japanese in WW-II.

C/ns:	5/9
Registrations:	CF-AMP/CF-AMT

The last Boeing 40C, NC841M, operating on skis. (*Boeing Photo P-40393*)

The Canadian-built Model 40H-4 was identical to the American 40B-4. (*Photo by Gordon S Williams*)

The single Model 40X was a 40C airframe with a second open cockpit in place of the two rear cabin seats. (*Boeing Photo 2112-B*)

The Model 40Y was generally similar to the 40X but used the Hornet engine and balanced rudder of the 40B-4 and such refinements as engine cowling and wheel pants. (*Photo by Arthur E Price*)

• 40X – The 40X was built to special order for the Associated Oil Company and carried its special colours. The aeroplane was a modified 40C airframe with the cabin accommodation cut to two passengers and an extra open cockpit installed ahead of the normal pilot's cockpit. The aeroplane was delivered on September 6, 1928, and licensed under the 40C type certificate.

C/n: 1093
Registration: NC-7526

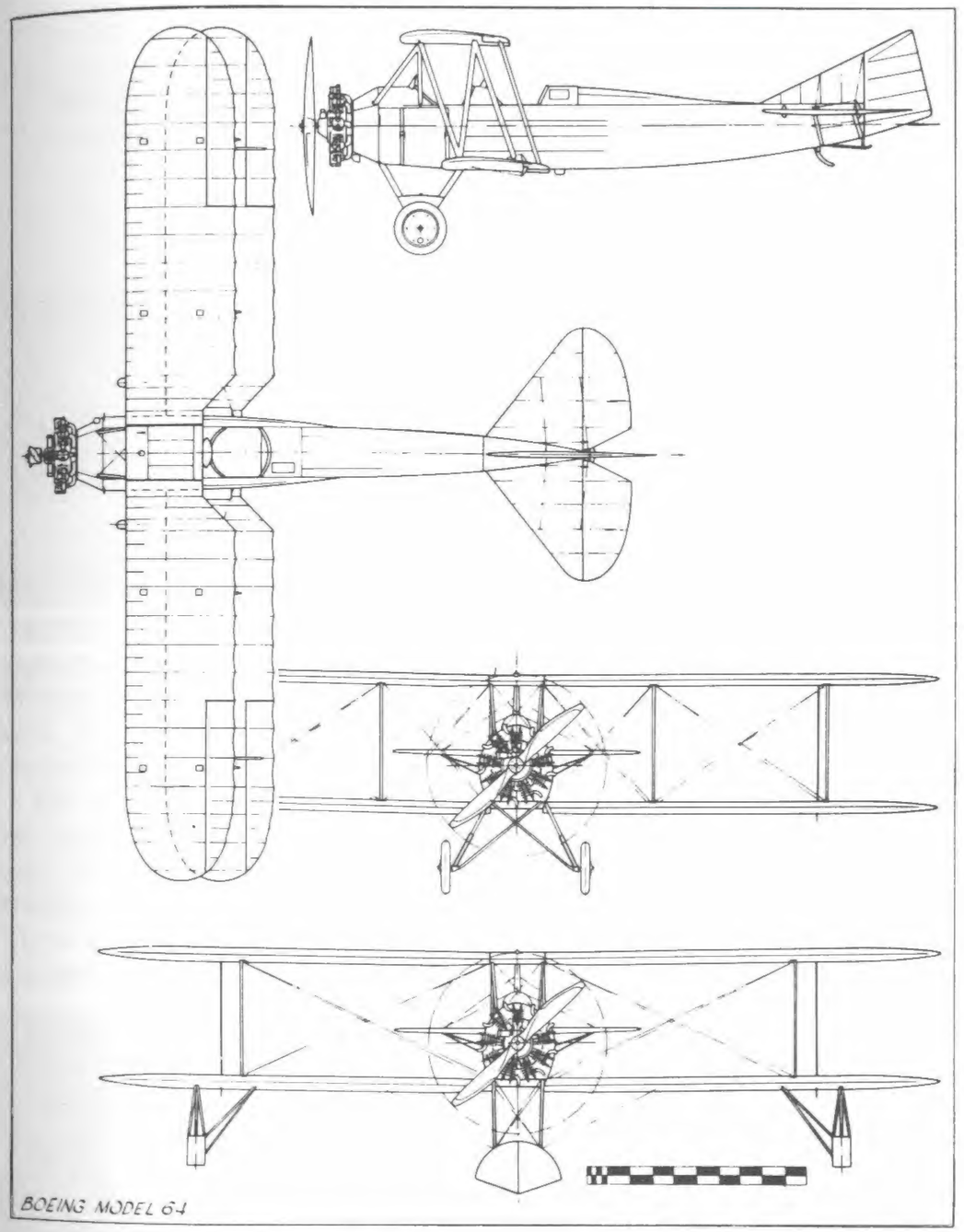
• 40Y – The single 40Y was another custom conversion of a 40C airframe, similar in seating arrangement to the 40X and the dual-control 40B conversions, but using a Hornet engine in place of the C's Wasp. The 40Y was turned over to the customer, the Standard Oil Company of California, on December 9, 1928, the day before the first flight. It was initially approved under Memo 2-30 as a 40B but was eventually licensed under the 40B-4 ATC No. 183.

C/n: 1095
Registration: NC-381

MODEL 64 – The Model 64 was built at company expense and submitted to the Army and the Navy as both a primary and a gunnery trainer. Because of the spin problems with the NB series, the Model 64 reverted to an older and thinner aerofoil, and used two bays of struts to brace the thin wings. Later experiments were conducted with a wing using a thicker Munk (NACA) M-12 aerofoil and only one bay of struts.

Construction was welded steel tube fuselage and tail surfaces with wood wing spars and ribs. While the Model 64 flew mostly in the primary trainer configuration, a removable rear cockpit superstructure was built to carry the mounting ring for a flexible machine gun. A fixed gun could be mounted ahead of the front cockpit, and synchronized to fire through the propeller.

Model 64 in original configuration with two-bay thin wings and contemporary Army-Navy tail markings, March 6, 1926. (*Boeing Photo P-1165-B*)



The Model 64 flew in February 1926, carrying only Navy-type tail stripes for markings. The first flight with the single-bay wings was on August 31, 1926, and this time the aircraft carried the new Boeing-designed tail stripes later adopted by the Army.

The aeroplane was sold to Pacific Air Transport and was later resold to a private owner after being fitted with a 220 hp Wright J-5 engine. A second Model 64 was started but not completed, according to Boeing records, although CAA records indicate that two Model 64s were licensed under Memo 2-43 of February 21, 1929.

Seaplane version of Model 64 with one-bay wings of thicker aerofoil and initial application of the Boeing-designed tail marking later adopted by the Army Air Corps. (*Photo by Arthur E Price*)

TECHNICAL DATA - MODEL 64

Type:	Trainer
Accommodation:	2 crew
Power plant:	Wright J-3 200 hp
Span:	36 ft 10 in
Length:	25 ft 4½ in
Height:	11 ft 1 in
Wing area:	344 sq ft
Empty weight:	2,140 lb (sea)
Gross weight:	2,840 lb (sea)
Max speed:	93·3 mph (sea) 98·5 mph (land)
Cruising speed:	84 mph (sea)
Climb:	410 ft/min (sea)
Service ceiling:	7,500 ft (sea)
Range:	250 miles
Armament:	One or two ·30 cal MG
C/ns:	804, 877
Registration:	7268 (804)

MODEL 80 - The success of the passenger-carrying phase of the San Francisco—Chicago route of Boeing Air Transport indicated the desirability of using aeroplanes designed for the purpose, so a 12-passenger trimotor transport was designed early in 1928 and first flown in August 1928.

Fuselage construction was welded steel tubing with wire bracing aft of the cabin. The wing spars and ribs were welded steel-tube trusses with

The third Model 80 with the original vertical tail configuration. The 'B-Line' emblem is carried on the aft fuselage and the regular Boeing Air Transport emblem is on the nose. (*Boeing Photo*)

detachable wood-frame wing tips as on the PB-1 flying-boat (Model 50). The passenger seats were arranged in four rows, four single seats on the right-hand side of the cabin and four doubleseats on the left-hand side. With the engines and undercarriage installed, the centre section was integral with the fuselage and the outer wing panels were removable at the centrelines of the nacelles. Licensed under Memo 2–4 on October 22, 1928.

The four Model 80s were painted all silver with International orange on the upper surface of the top wing. Two, NC-7135 and NC-7137 (c/ns 1030 and 1032) were modernized as Model 80 Specials with revised nose contours, new tail surfaces, and drag rings around the outboard engines. These changes required the issue of a new Memo Approval, 2-321 of January 21, 1931.

Cabin of the 12-passenger Model 80. Note overhead baggage racks and individual reading lights. The 18-passenger 80A had a higher ceiling and two more rows of three-abreast seats. (*United Air Lines Photo 3856-6*)

TECHNICAL DATA - MODEL 80

Type:	Passenger transport
Accommodation:	12 passengers, 3 crew, 1,000 lb cargo
Power plant:	3 P & W Wasp 410 hp
Span:	80 ft
Length:	54 ft 11 in
Height:	14 ft 8 in
Wing area:	1,220 sq ft
Empty weight:	9,231 lb
Gross weight:	15,276 lb
Max speed:	128 mph
Cruising speed:	115 mph
Climb:	700 ft/min
Service ceiling:	14,000 ft
Range:	545 miles
C/ns:	1030/1033
Registrations:	7135/7138

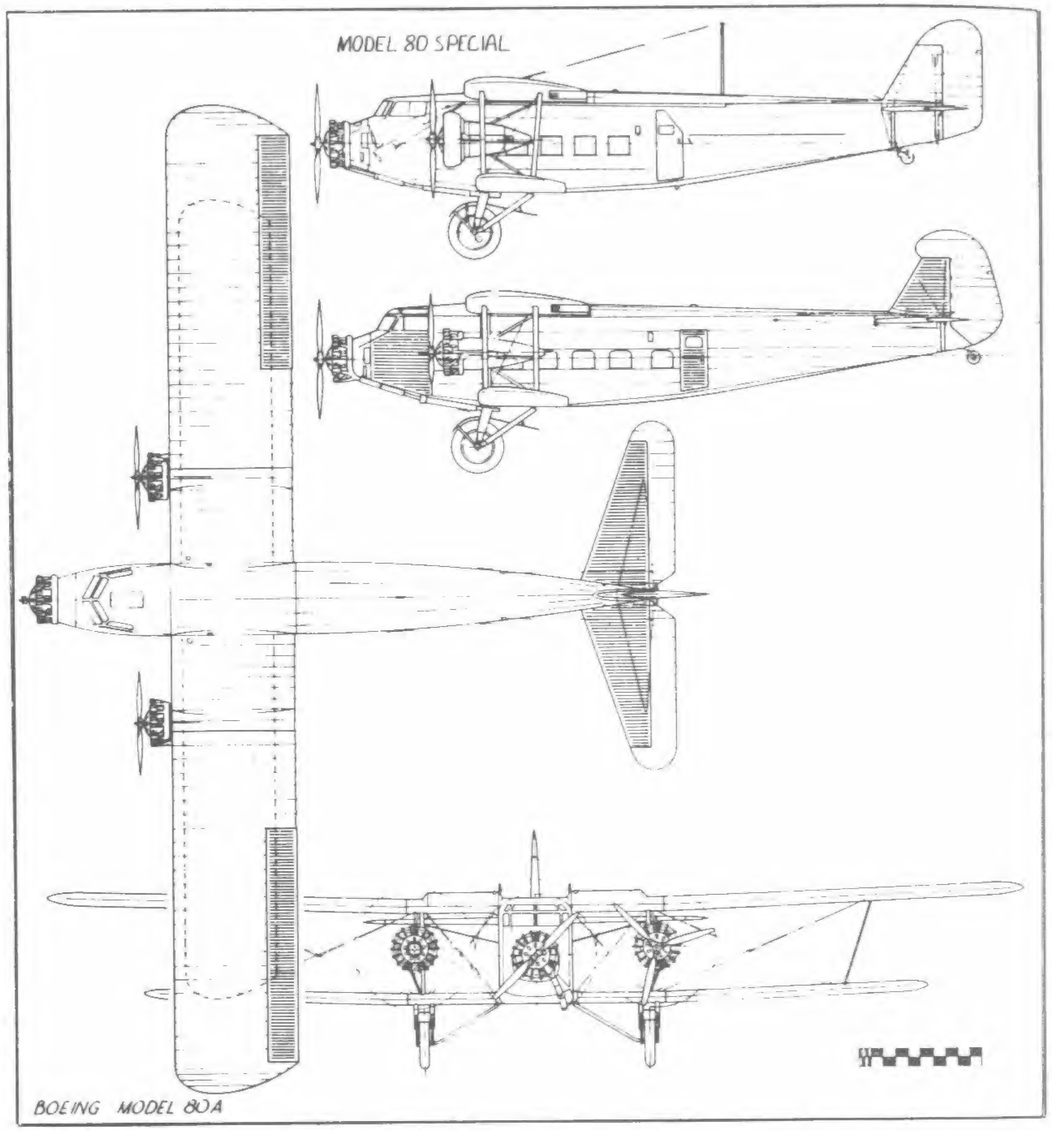
Two of the four Model 80s were modernized and re-certificated as Model 80 Special. Note the modified nose, side engine cowlings, and new vertical tail surfaces. (*Photo by Gordon S Williams*)

MODEL 80A - An improved model of the 80, the principal differences being the installation of P & W Hornet engines in place of Wasps and a redesign of the upper wing to bring the spars closer together so that the front and rear interplane struts were parallel. The fuselage structure was changed to bolted square aluminium tubing aft of the cabin. The spars and ribs differed from those of the Model 80 in using square-section aluminium tubing bolted into trusses instead of using welded round tubing. With the additional power, passenger seating was increased to a total of 18, and a new feature was added to airline travel - a stewardess, actually a registered nurse, sat on a jump seat at the rear of the cabin. Streamlining was greatly improved over that of the 80 by refinement of the nose contours and the addition of NACA cowlings. The cowlings were removed after the aeroplanes entered airline service. Twelve 80A airframes were started, but only 10 were completed as 80A, the 11th being converted to Model 226 and the 12th to Model 80B. All 80As (ATC-206) were later modified to Model

The first two Model 80As were delivered with fully cowled engines and the small vertical tail. The others had uncowled engines and larger vertical tails. The first two were modified to conform. (*Boeing Photo*)

The ten Model 80As were modified to 80A-1 by fuel system changes and the addition of auxiliary rudders and vertical fins. (*Photo by Gordon S Williams*)

Pilot's cockpit of Model 80A. Engine instruments are in triplicate between the pilots but the single primary flight instruments are concentrated in front of the First Pilot's seat at the left. (*Boeing Photo 3065-B*)



80A-1. The 80As were delivered in the new standard Boeing grey colour scheme with green fuselage and a tail trim and orange on top of the upper wing. The price quoted for a Model 80A at the factory was $75,000.

TECHNICAL DATA - MODEL 80A

Type:	Passenger transport
Accommodation:	18 passengers, 2–3 crew, 898 lb cargo
Power plant:	3 P & W Hornet 525 hp
Span:	80 ft
Length:	56 ft 6 in
Height:	15 ft 3 in
Wing area:	1,220 sq ft
Empty weight:	10,582 lb
Gross weight:	17,500 lb
Max speed:	138 mph

Cruising speed:	125 mph
Climb:	900 ft/min
Service ceiling:	14,000 ft
Range:	460 miles
C/ns:	1081/1090
Registrations:	793K, C-224M/C-232M

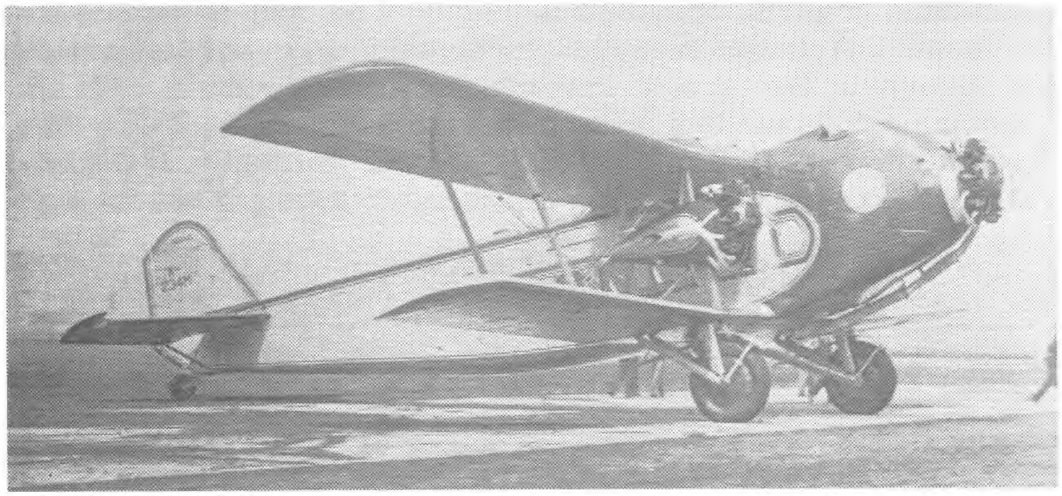
MODEL 80A-1 – The ten 80As were redesignated as 80A-1 following a modification programme that added tail area in the form of two auxiliary fins and rudders mounted on each side of the main rudder and decreased the fuel capacity to 392 gal because of a higher empty weight of 10,735 lb. Following withdrawal from airline service when replaced by Boeing 247s, one 80A-1 was assigned to the Boeing School of Aeronautics at Oakland, California. Another (224M) was fitted as an electric signboard for night

The second 80A, NC224M, was modified for hauling bulk cargo in Alaska during World War II. It had a large cargo door cut into the fuselage; this required external steel trusses beneath the fuselage to reinforce the structure. (*Photo by Logan Coombs*)

This 11,000 lb boiler being loaded into NC224M in 1942 was the heaviest item ever air-lifted up to that time. Normal useful load for an 80A (payload plus fuel and crew) was 7,083 lb. (*Courtesy Bob Dickson*)

advertising in the Los Angeles area before being sent to Alaska during WW-II. This aeroplane was then modified by the installation of a large cargo door on the starboard side of the fuselage, which required the addition of an external truss to carry the tail loads past the cut-out.

This last example of the Boeing 80-series was salvaged from an Alaskan dump in 1964 and transported to Seattle in a US Air Force Douglas C-124. It was rebuilt to display condition by 1980 and is now on display at the Museum of Flight in Seattle, Washington.



The Model 80B in its original open-cockpit configuration prior to conversion to 80A-1. (*Photo by John W Goodwin*)

MODEL 80B – The last of the 12 original 80A airframes was redesignated following redesign of the nose to accommodate an open cockpit because of pilot resistance to the 'new' closed cockpit of the Model 80. The pilot's and co-pilot's seats were raised to permit backward visibility over the wing. Operated as 80B-1 with 575 hp Hornets under Memo 2-248 issued August 6, 1930, the 80B was otherwise identical to the 80As and was converted to an 80A-1 by Boeing Air Transport after the pilots were convinced of the advantages of enclosed cockpits.

C/n: 1092
Registration: NC-234M

MODEL 81 (XN2B-1) – Two primary trainers were developed from the thick-wing version of Model 64 and were powered with the new and unconventional Fairchild-Caminez 4-cylinder radial engine. This 125 hp innovation was fitted with cams that connected the crankshaft to the pistons and produced a full power cycle for one revolution of the shaft instead of the usual two. Crankshaft speed was only 1,000 rpm and required the use of a large-area high-pitch propeller. Both two and four-blade types were tried with the engine. The Model 81 was sold to the Navy as XN2B-1 for $8,300 and delivered to the test centre at Anacostia, Maryland, on June 21, 1928.

The second of two Model 81s, fitted with Fairchild-Caminez engine and delivered to the US Navy as XN2B-1. (*Boeing Photo 1955-B*)

Replacement of the Caminez engine of the XN2B-1 with a 165 hp Wright J-6-7 Whirlwind did not result in a change of dash number as was customary. Overall chrome yellow was standard colouring for US Navy primary trainers at the time. (*Courtesy F H Dean*)

The first Model 81, redesignated 81A when fitted with Axelson engine in December 1928. (*Boeing Photo 2266-B*)

The potentialities of the aeroplane were severely handicapped by the troublesome experimental engine, so on January 10, 1929, the Navy sent it to the Wright Aeronautical Corporation for installation of the proven 165 hp Wright J-6-5 (R-540) radial. The aeroplane designation was not changed as would be expected from such a major alteration, and, in spite of greatly increased performance and a rating of suitability as a type, the XN2B-1 was not ordered into production.

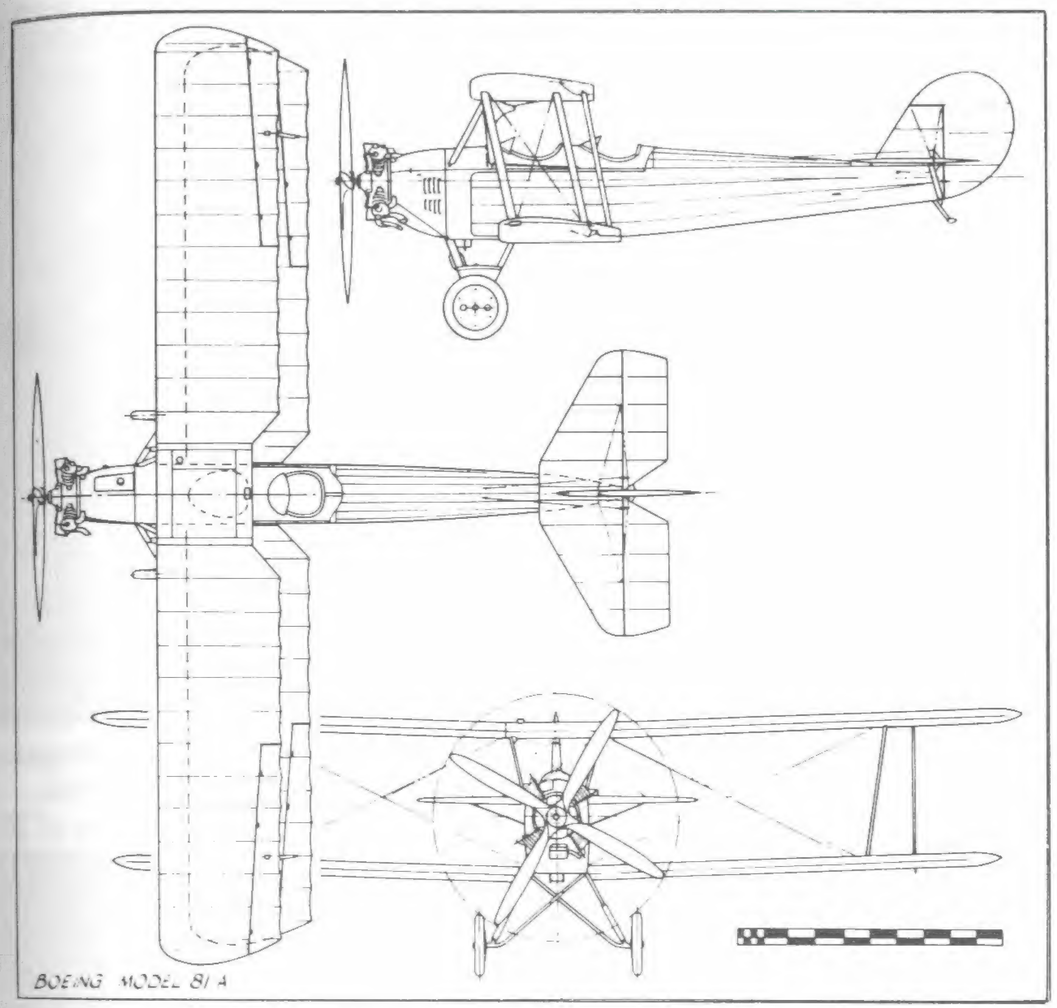
TECHNICAL DATA - XN2B-1

Type:	Trainer
Accommodation:	2 crew
Power plant:	Fairchild-Caminez 125 hp
Span:	35 ft
Length:	25 ft 8 in
Height:	11 ft 2in
Wing area:	295 sq ft
Empty weight:	1,652 lb (Caminez)
Gross weight:	2,178 lb (Caminez)
Max speed:	103·9 (Caminez), 113 mph (R-540)
Cruising speed:	86 mph
Climb:	515 ft/min (Caminez), 770 ft/min (R.540)
Service ceiling:	12,000 ft (Caminez), 13,300 ft (R-540)
Range:	335 miles
C/n:	1038
Navy serial number:	A-8010

MODEL 81A - The first of two Model 81 airframes was fitted with a 145 hp Axelson engine after tests with the original Fairchild Caminez. The Model 81A, which first flew as such on December 27, 1928, was delivered to the Boeing School of Aeronautics* at Oakland, California.

C/n:	1037
Registration:	X-63E

* The Boeing School of Aeronautics was founded by the Boeing Air Transport System in 1929, originally to train the airline's pilots and mechanics. It soon expanded to offer piloting, aeronautical engineering, and other aviation-oriented courses to the public. Following the break-up of United Aircraft and Transport, the School remained with the new United Air Lines but retained the Boeing name for the remainder of its existence. The author was an engineering student there 1940–41.



MODEL 81B - The original 145 ph Axelson engine in the 81A was not satisfactory, and was changed at the Boeing School to a 115 hp Axelson. The aeroplane was redesignated Model 81B and licensed without an Approved Type Certificate under Memo 2-147. This engine was later replaced by a 5-cylinder Wright J-6-5 of 165 hp and the aeroplane was flown experimentally under the same designation.

MODEL 81C - The Model 81B was further modified at the Boeing School of Aeronautics by the installation of a 100 hp Kinner K-5 five-cylinder radial engine and redesigned vertical tail surfaces. This change resulted in the aeroplane being given an experimental licence until the new installations were proved satisfactory. Following withdrawal of the single civil Model 81 from flight training, an unairworthy Axelson engine was re-installed and the aeroplane was used as a fully-assembled classroom maintenance trainer at the Boeing School of Aeronautics until that establishment was taken over by the Army in 1942.

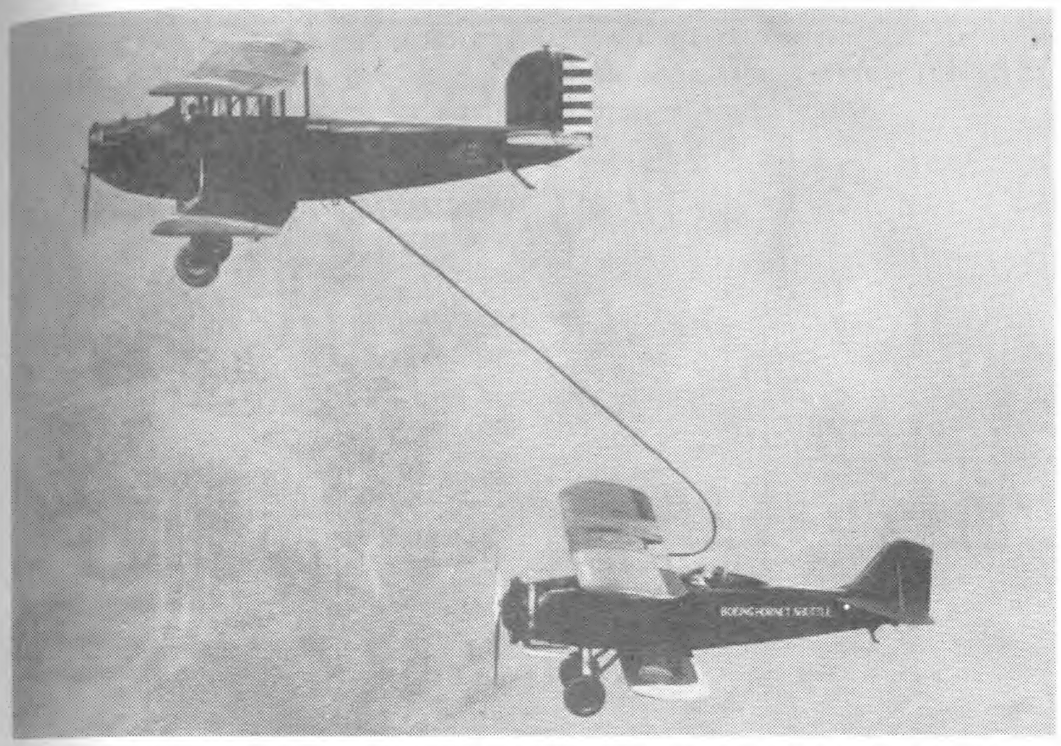
The Model 81A converted to 81C with Kinner engine, Goodyear airwheels, and modified vertical tail surfaces. (*Photo by Gordon S Williams*)

MODEL 95 – The Model 95 was designed in 1928 as an all-mail-and-cargo aeroplane and followed the classic mailplane lines by locating the pilot in an open cockpit aft of the cargo compartment. Fuselage construction utilized the new bolted square dural arrangement perfected on the Model 83/89 fighters (Chapter 5), and the wings were built with two wooden box spars and bandsawed plywood ribs using a combined Boeing 109/106 aerofoil.

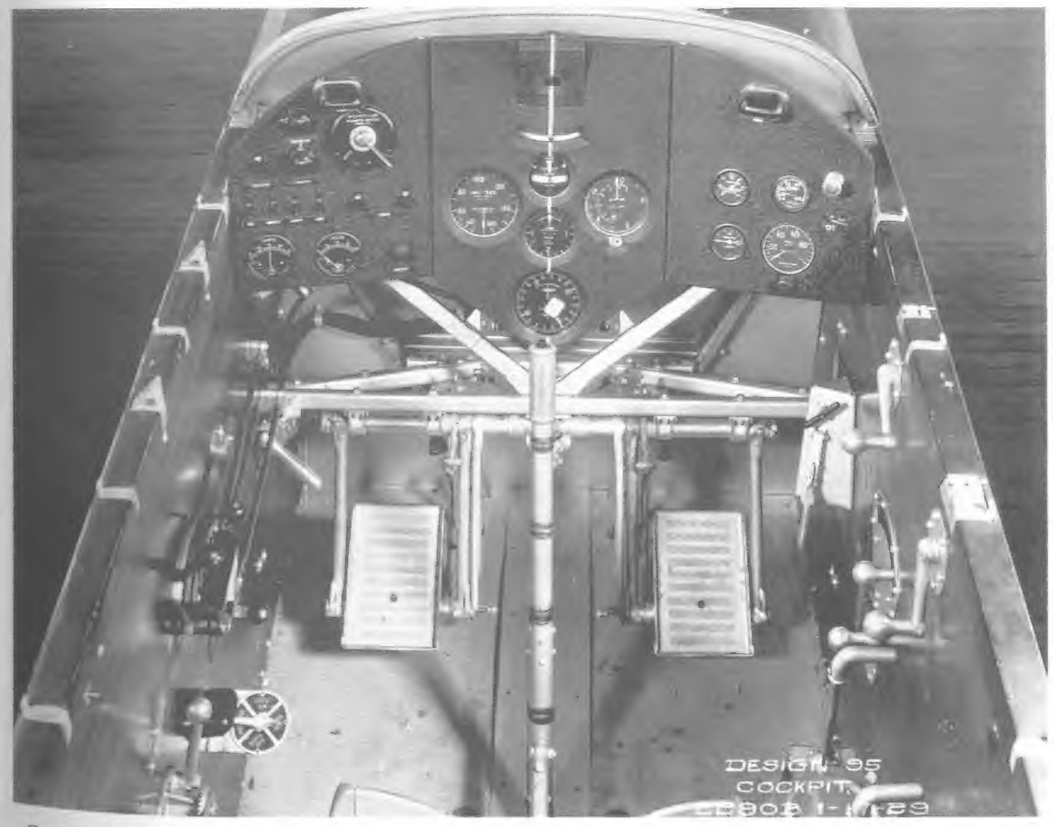
The Model 95 made its first flight on December 29, 1928. The first of 25 built was delivered on January 18, 1929, and the last on May 8 under ATC 106. Twenty were delivered to Boeing Air Transport, one to National Air Transport (part of the Boeing Air Transport system), and four to Western Air Express. The advertised price was $24,500.

One Model 95, C-397E (c/n 1057), was modified to a two-seater for a series of endurance flights and made several nonstop transcontinental flights refuelled from specially modified 40B-4s and an Army Douglas C-1 before crashing in a storm without injury to the crew. For this special programme

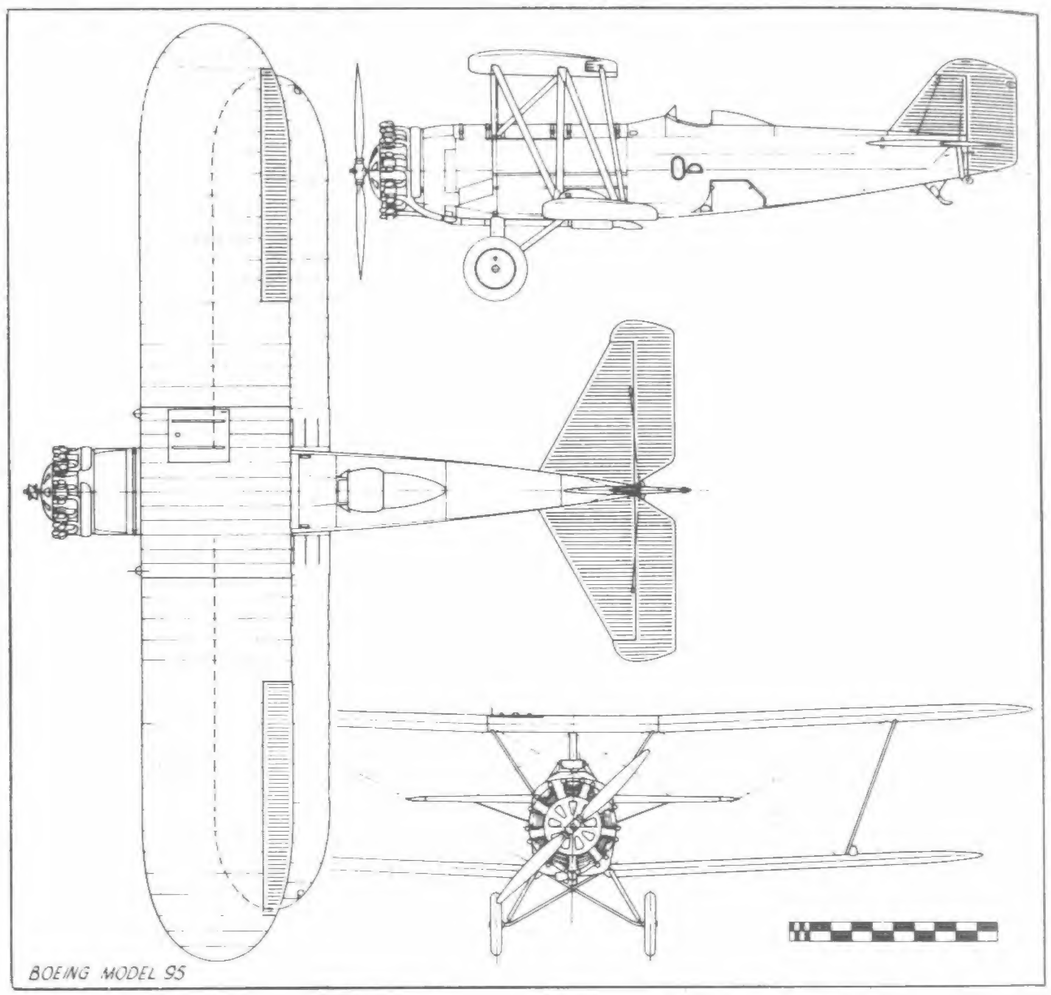
Single-seat Model 95 mail/express biplane. Compare outlines to biplane fighters derived from Models 83/89 and to later Model 203 trainer. (*Boeing Photo P-2272-B*)



Boeing's first in-flight refuelling experience was obtained in 1929 with the 'Boeing Hornet Shuttle', here being refuelled by an Air Corps Douglas C-1 tanker. (*USAF Photo*)



Cockpit of the Model 95 mailplane. Note use of suspended rudder pedals instead of rudder bar of Model 40A. Rudder pedals also actuate wheel brakes. (*Boeing Photo 2290-B*)



Former airline Model 95 modified for use as a single-seat bomber in Honduras. (*E M Sommerich Collection*)

it was given a restricted licence and the registration number became R-397E. A number of other 95s, retired from the airlines, were acquired by various Latin American nations and converted to bombers.

TECHNICAL DATA - MODEL 95

Type:	Mailplane
Accommodation:	1 pilot
Power plant:	P & W Hornet 525 hp
Span:	44 ft 3 in
Length:	31 ft 11 in
Height:	12 ft 1 in
Wing area:	490 sq ft
Empty weight:	3,196 lb
Gross weight:	5,840 lb
Max speed:	142 mph
Cruising speed:	120 mph
Climb:	950 ft/min
Service ceiling:	16,000 ft
Range:	520 miles
C/ns:	1046 to 1070
Registrations:	C-183E/C-192E, C-417E, C-397E, C-412E/C-415E, C-418E/C-426E (all later NC)

MODEL 95A - The 16th Model 95 was tested at the factory with a lower-powered Pratt & Whitney Wasp engine in place of the Hornet and was given the designation of 95A. Limited approval was obtained under Memo 2-411 on May 25, 1932, but the modification was not extended to other models.

C/n:	1061
Registration:	C-415E

MODEL 203 - In March 1929, a design was initiated for a low-powered two-to-three seat biplane equivalent in size and performance to the Wacos, Eaglerocks, Travel Airs, and other standard training and utility biplanes then in production. The front cockpit could accommodate either two passengers side-by-side or a student with a second set of controls and instruments. The design resembled a combination of the Model 95 and the 100/P-12/F4B series. Wings used solid wood spars and plywood ribs and the fuselage used welded steel tubing. The Model 203 was the last original Boeing design to use the welded steel fuselage although Stearman, a United Aircraft subsidiary at the time it bought the design rights to the 203, continued to use it for trainers built through WW-II.

Four of the five Model 203s built at the factory were completed with 7-cylinder Axelson radial engines, 145 hp for the first and 165 hp for the others. The first 203 flew on July 1, 1929, and carried the standard Boeing

The third Model 203 with the original small tail, Axelson engine, and the markings of the Boeing School of Aeronautics. Photographed before delivery, on October 25, 1929. (*Boeing Photo P-2655-B*)

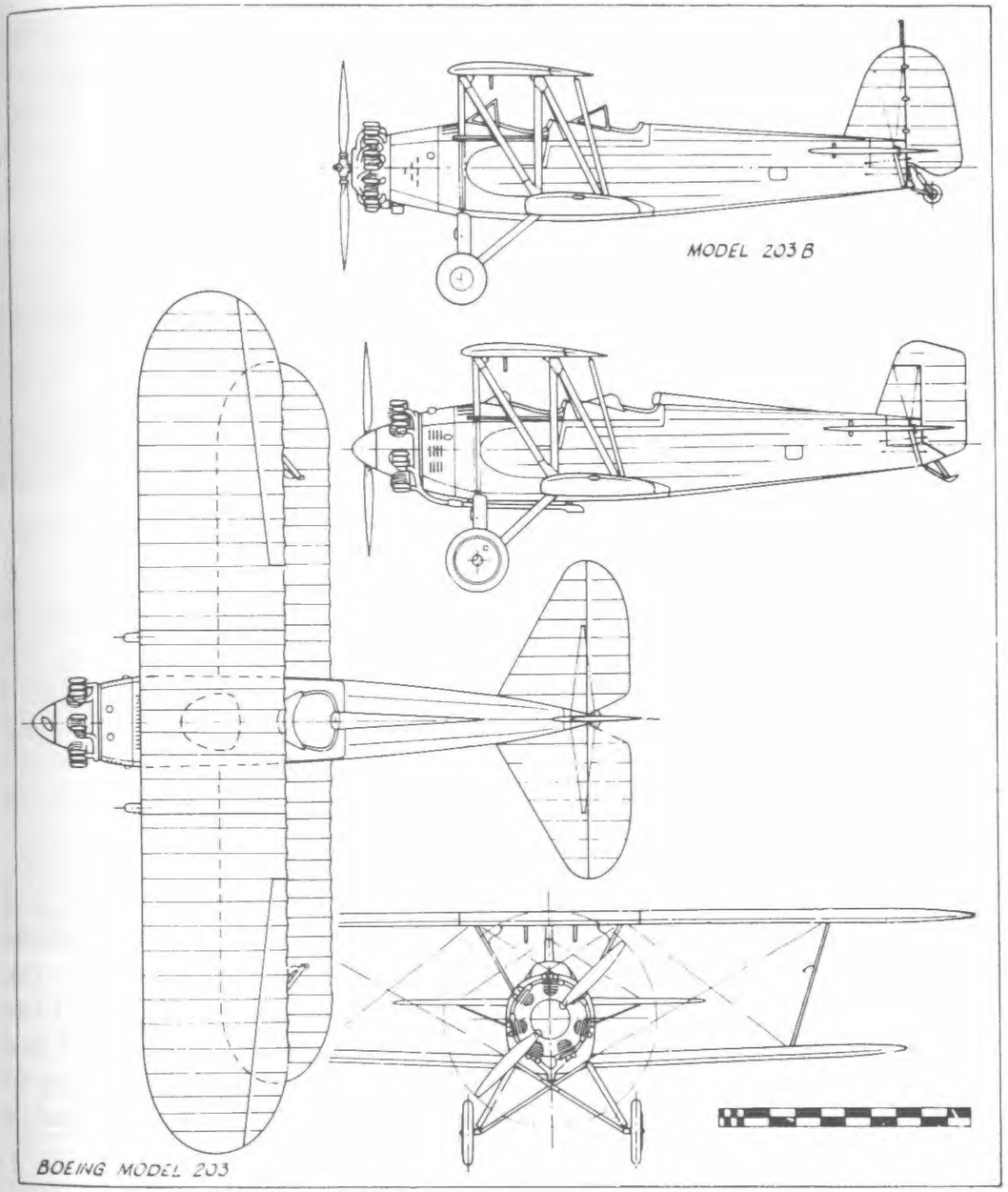
grey colour scheme with green trim on fuselage and tail and Internatinal orange on the top surface of the upper wing. This was changed to an all-green fuselage when the aeroplanes were licensed under Memo 2-139 and delivered to the Boeing School of Aeronautics at Oakland, California. The four 203s were later converted to Model 203A at the school.

TECHNICAL DATA - MODEL 203

Type:	Trainer
Accommodation:	1–2 passenger, 1 pilot
Power plant:	Axelson 145–165 hp
Span:	34 ft
Length:	24 ft 4 in
Empty weight:	1,896 lb
Gross weight:	2,625 lb
Max speed:	108 mph (145 hp)
Cruising speed:	92 mph
Range:	400 miles
C/ns:	1137, 1139 to 1141
Registrations:	976H/979H (later NC)

MODEL 203A – The second of five basic Model 203s built at the factory was completed as Model 203A and differed from the others only in being fitted with a 165 hp 5-cylinder Wright J-6-5 engine. It first flew on August 29, 1929, and was delivered to the Boeing School together with the other 203s, all of which were later converted to 203A under ATC 211 by change to the Wright engine.

After several years of service, the vertical tail surfaces of the 203As were redesigned and enlarged along the revised contours that had appeared on the final version of the Model 218. Two additional 203s were built at Boeing



School, c/n 1940 in 1935 and c/n 1986 in 1936. To qualify for licences under the original type certificate issued for the Model 203A, Boeing factory serial numbers were assigned to these school-built aeroplanes.

Three of the 203As were converted to Model 203B by engine change and the remaining four 203As continued in use as primary trainers at Oakland until transferred to the United Air Lines base at Cheyenne, Wyoming, after American entry into WW-II.

C/ns:	1138, 1940, 1986
Registrations:	C-587K, NC-12748, NC-13392

The third Model 203 after conversion to 203A with Wright engine at Boeing School. This 1940 photo shows later tail shape revision and change to airwheels. (*Photo by Peter M Bowers*)

MODEL 203B – The factory-built Model 203A and the two 203As built at the Boeing School of Aeronautics were converted to Model 203B by the installation of 9-cylinder Lycoming R-680 radial engines of 220 hp. Fitted with more advanced equipment than the primary trainers, including instrument hoods, these machines were used by the school's more advanced pupils. Factory records do not show performance figures resulting from the conversion, which was approved under Memo 2-412.

By the time the last 203B conversion was completed at the school in 1941, the Boeing School was beginning to abandon its traditional grey, green, and orange colour scheme and the third 203B was completed in all Cadmium red with white trim. The other surviving 203B was soon refinished in the same colouring, but the 203As retained their original colouring until the cessation of school activities due to WW-II. The two 203Bs were sold to a private owner who converted them to dusters after the war, and they were in use as such as late as 1950. One additional 203A was eventually converted to 203B for a total of four – c/ns 1138, 1140, 1940, 1986.

The second 203A built at Boeing School after conversion to 203B by installation of Lycoming engine. (*Photo by Peter M Bowers*)

MODEL 6D (B-1D) – Although this model number continues the designation adopted for the B-1 flying-boat of 1919 (Boeing Model 6) described in Chapter 1, the Models 6D and 6E are described in this chapter because of the nine-year time lapse and the fact that they are more closely related to later models and qualify as entirely new designs.

The first Model B-1D flying-boat with 220 hp Wright J-5 engine. (*Boeing Photo P-1927-B*)

The designation of B-1D (ATC 23) was assigned to two aeroplanes in a batch of eight designed in 1928 and built between May 1928, and April 1929. Company records carry them as four-seat developments of the B-1 of 1919 but the only feature in common is the general layout of a biplane pusher flying-boat. The only detail similarity was in the shape of the rudder, all other structural details being completely new.

The B-1D hull structure used wooden longerons to form a rectangular-section framework covered with cross strips of spruce veneer and the wings were merely shortened Model 40 panels that retained the asymmetric separation line of the upper wing of the port side of the engine mount.

The first B-1D completed (c/n 1029) flew in April 1928, and was fitted with a 220 hp Wright J-5 Whirlwood radial engine driving a wooden propeller. This machine was sold to a Canadian owner. The second (c/n 1028) was fitted with a 420 hp P & W Wasp engine that gave it a performance exceeding that of the later B-1E because of using the B-1E power plant in a lighter airframe.

TECHNICAL DATA - B-1D

Type:	Passenger flying-boat
Accommodation:	1 pilot, 3 passengers in one cabin
Power plant:	Wright J-5 220 hp
Span:	39 ft 8¼ in
Length:	30 ft 9 in
Height:	12 ft
Wing area:	466 sq ft
Empty weight:	2,442 lb
Gross weight:	3,442 lb
Max speed:	95 mph
Cruising speed:	80 mph
Service ceiling:	12,000 ft
Range:	175 mph
C/ns:	1028, 1029
Registration:	NC-5270, G-CASX

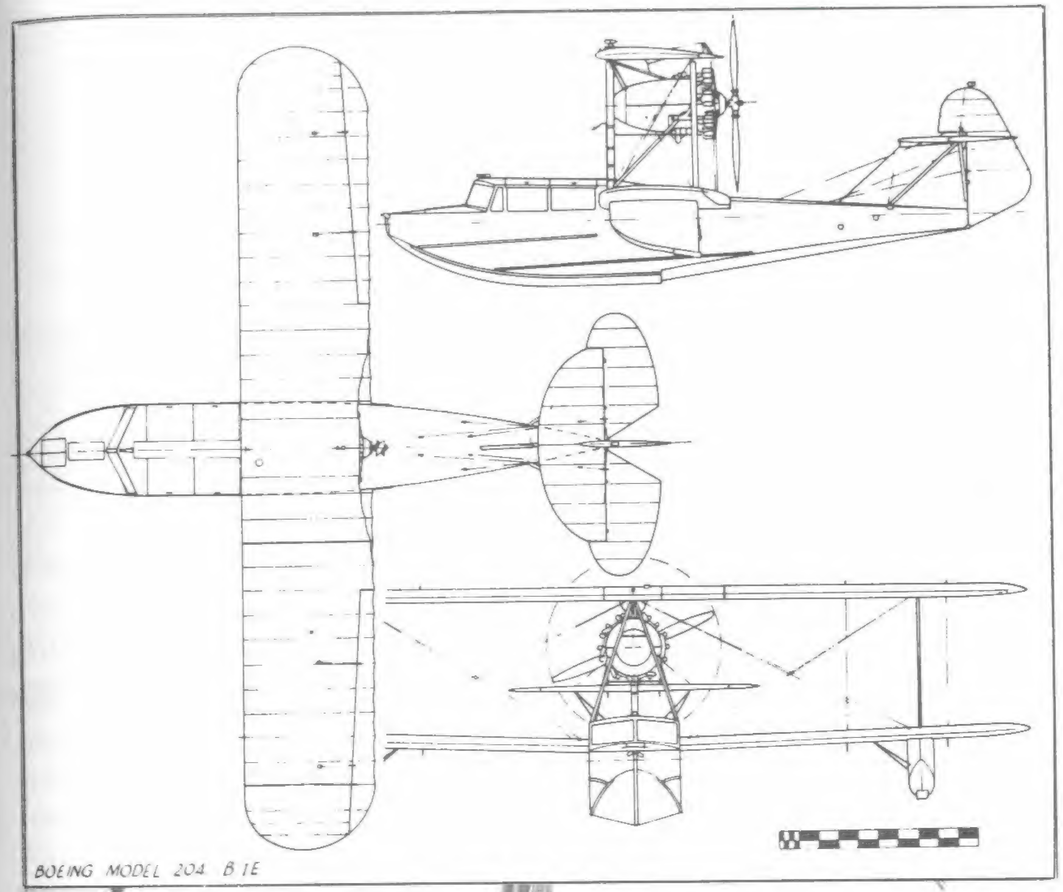
MODEL 6E (B-1E) – The B-1E was identical to the first B-1D except for power plant and heavier construction. Although carrying a later designation, the first B-1E carried an earlier Boeing serial number than the first B-1D. The second B-1E was the first in a batch of 10 that was redesignated Model 204 after the fifth machine was completed. First flight of the B-1E was on March 4, 1928. Principal outward recognition features were the larger engine and a redesigned rudder. All B-1Es flew under ATC 64 except the fifth (NC-115E, c/n 1074), which was licensed under Memo 2-215.

TECHNICAL DATA - B-1E

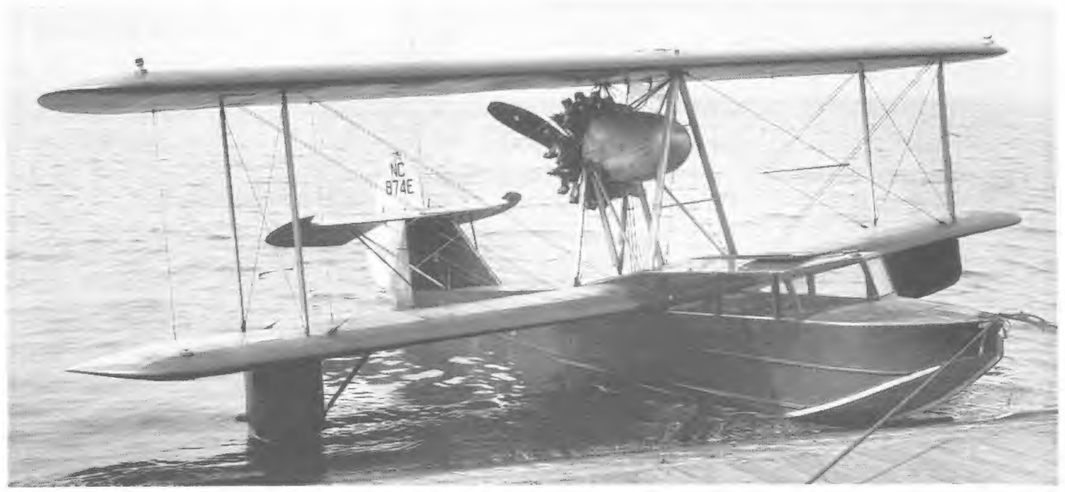
As B-1D except:

Power plant:	P & W Wasp 410 hp
Length:	32 ft
Empty weight:	3,090 lb
Gross weight:	4,550 lb
Max speed:	115 mph
Cruising speed:	105 mph
Climb:	1,000 ft/min
Service ceiling:	12,000 ft
Range:	450 miles
C/ns:	1027, 1071/1075
Registrations:	G-CATY, G-CAUF, NC-116E, CF-ABA, NC-115E, CF-ABB

MODEL 204 – The Model 204 was a redesignation of unbuilt B-1Es given a new model number to indicate that they were a 1929 design rather than a direct development of the B-1 of 1919. Outwardly, it was indistinguishable from the B-1E but the increase in capacity to five seats and other changes



There were sometimes notable internal differences between basically similar models. This first B-1E flying-boat has a single stick and a rudder bar for the pilot. Later B-1Es and 204s had a single wheel control and suspended rudder pedals. The dual-control Model 204A reverted to sticks but had suspended rudder pedals. (*Boeing Photo 1693-B*)



The first Model 204, essentially a redesignated B-1E (*Photo by Gordon S Williams*)

resulted in the issue of a new Approved Type Certificate, ATC 157. Five 204s were started at an advertised price of $20,000 but only the first two were completed at the factory, one as 204 and the other as 204A. A third, using the previously-assigned factory serial number and civil registration, was completed by a private owner who bought the unfinished machines.

TECHNICAL DATA - MODEL 204

Type:	Passenger flying-boat
Accommodation:	4 passengers, 1 pilot, in one cabin
Power plant:	P & W Wasp 410 hp
Span:	39 ft 8¼ in
Length:	32 ft 7 in
Height:	12 ft
Wing area:	470 sq ft
Empty weight:	3,298 lb
Gross weight:	4,940 lb
Max speed:	115 mph
Cruising speed:	95 mph
Climb:	1,000 ft/min
Service ceiling:	9,000 ft
Range:	350 miles normal, 525 miles with 120 gal fuel
C/ns:	1076, 1078
Registrations:	NC-874E, NC-876E

MODEL 204A - The Model 204A was the second factory-built 204 completed as a dual-control machine to the special order of William E Boeing and licensed under Memo 2-380. Later, under the ownership of Percy Barnes, it flew mail in a continuation of the Seattle–Victoria International Air Mail contract signed by Edward Hubbard in 1920. This contract continued into 1937.

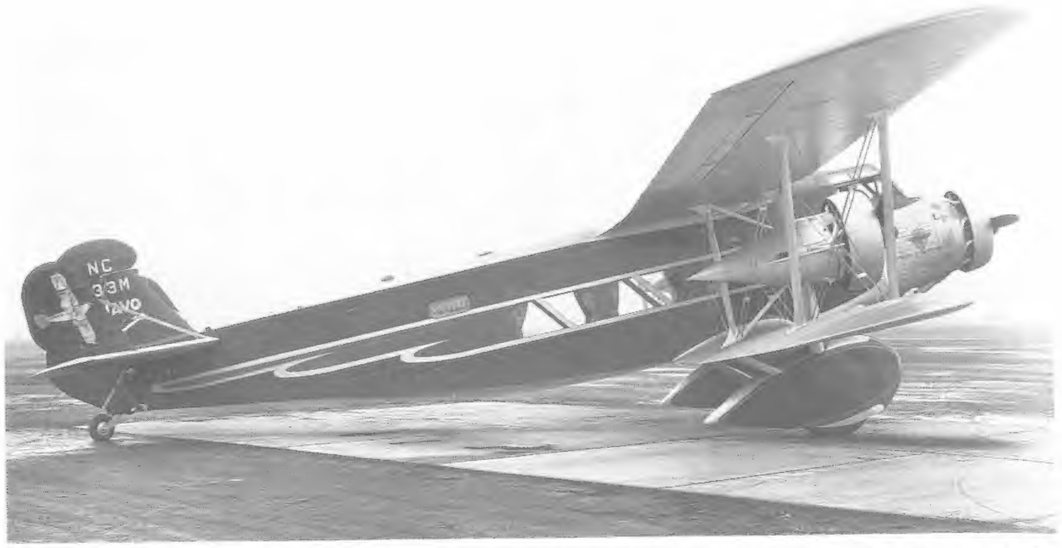
C/n: 1077 *Registration:* NC-875E

The second Model 204 completed as the dual-control 204A for William E Boeing. (*Photo by Gordon S Williams*)

MODEL C-204 THUNDERBIRD - Four Seattle-designed 204s were built by Boeing-Canada under the designation of C-204 to distinguish them from the American product. The name Thunderbird was applied only to the Canadian model. These were the first aeronautical products of this firm, which had previously been a builder of boats.

C/ns: 1/4
Registrations: CF-ALA/CF-ALD

The first of four Thunderbirds, Model 204s built in Canada as C-204 to indicate their Canadian origin.
(*Photo by Gordon S Williams*)



Model 226, the eleventh Model 80A sufficiently modified with special features to justify a new model designation. (*Boeing Photo 4204-B*)

MODEL 226 – The Model 226 was the next-to-last aeroplane in the original batch of 12 Model 80As given a new model number and delivered to the Standard Oil Company of California as a deluxe executive transport under Memo 2-310 on December 20, 1930. The fuel capacity was increased to 658 gal, the passenger capacity was reduced, and a considerable amount of structural and aerodynamic refinement was incorporated. Large wheel fairings, or 'pants', were installed at the factory with anti-drag rings around

The luxurious cabin of the Model 226 executive transport for the Standard Oil Company of California. View looking forward. (*Boeing Photo 4190*)

The cabin of the Model 226, looking aft. (*Boeing Photo 4187*)

the engines, but these were removed in service. The cabin was entirely different to that of the airline model and included a revised lavatory, two convertible day beds, six adjustable overstuffed chairs, two side tables, two folding tables, gasoline stove, refrigerator, sink, enlarged windows, and special upholstery and panelling.

C/n: 1091
Registration: NC-233M

TOTEM – While Boeing-Canada produced mostly Seattle-designed aircraft, the Canadian staff developed a native design tailored to Canadian conditions. The Totem – no model designation known – was inspired by the C-204 Thunderbird and drew much of the design detail from it. Other than the monoplane configuration, the major change was in the materials. The hull was built up of Alclad (duralumin coated with a thin coat of pure aluminium) and steel ribs were used on wooden wing spars. Although a pure flying-boat design, provision was made for the addition of skis for operation from ice and snow.

TECHNICAL DATA – TOTEM

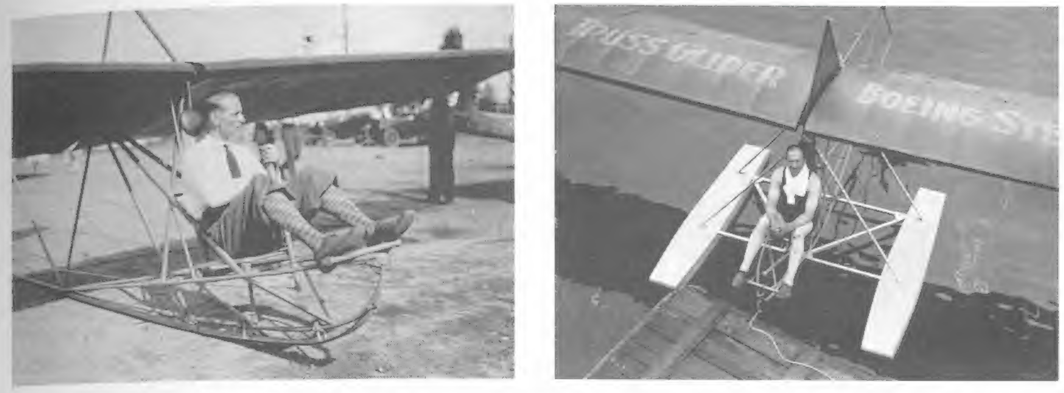
Type: Passenger flying-boat
Accommodation: 3 passengers, 1 pilot, in one cabin
Power plant: P & W Wasp Jr 300 hp
Span: 46 ft

The Totem, an original flying-boat design by Boeing Aircraft of Canada, Ltd. (*Courtesy Gordon S Williams*)

Length:	32 ft 9 in
Height:	11 ft 3 in
Wing area:	310 sq ft
Empty weight:	2,700 lb
Gross weight:	4,000 lb
Max speed:	122 mph
Cruising speed:	99 mph
Climb:	830 ft/min
Service ceiling:	17,000 ft
Range:	400 miles
C/n:	10
Registration:	CF-ARF

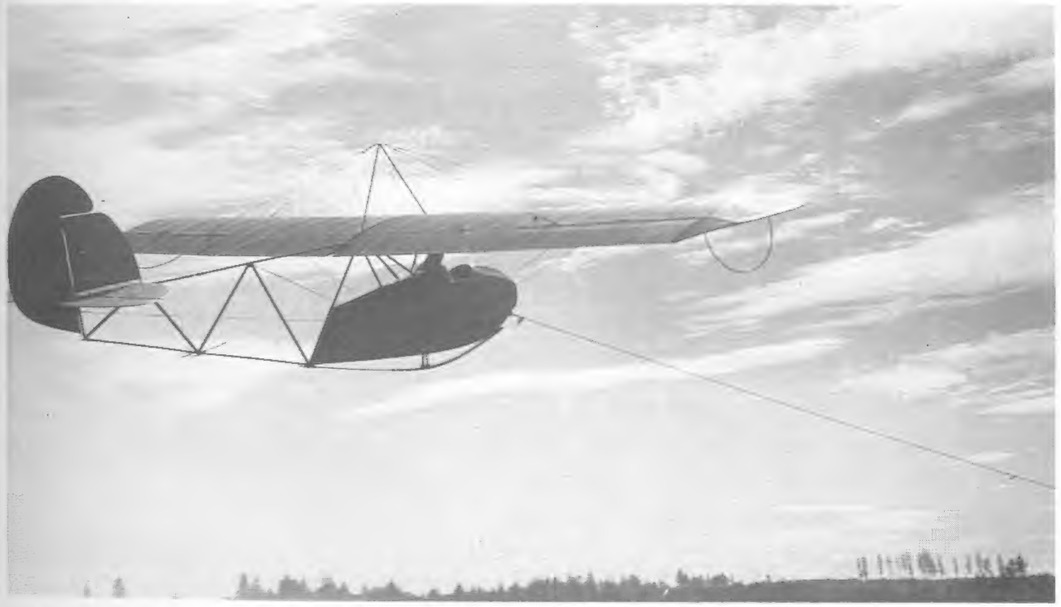
STEEL TRUSS GLIDER – The last original design of Boeing-Canada was an improved version of the then-popular primary glider, utilizing a welded steel tube truss for the openwork fuselage instead of the traditional wood. Because of this feature, it was advertised as the Boeing Steel Truss Glider. Wings were wood frame fabric-covered, and wooden sea-sled twin floats could be fitted for water operation. Because of the 'double' longeron construction in the area of the pilot, the primary glider was well suited to performance improvement through addition of a streamlined pod around the pilot's seat.

Several gliders were built, with minor variations in control surface shape, at the height of the world-wide economic depression. Purchases of purely recreational aircraft were at an all-time low, and the gliders did not find a ready market. Finally, to dispose of the gliders on hand, the company



The Steel Truss Glider differed from its many contemporaries not only in having steel in place of the wooden fuselage but in the design of the much more substantial forward fuselage structure. Note the plywood pontoons for water operations and the appropriate costume of the pilot. (*Boeing-Canada Photo*)

donated them as gate prizes to the Canadian National Exposition in Vancouver, B.C. This resulted in a rather odd assortment of glider owners, most of whom had absolutely no use for such a windfall. Youthful local flying enthusiasts kept track of the recipients, and, after a bit of campaigning, were able to obtain most of them for their own good use.



Canadian-built Boeing Steel Truss Primary Glider modified by adding a streamlined pod structure around the pilot's seat for improved performance. (*Courtesy Gordon S Williams*)

TECHNICAL DATA – STEEL TRUSS GLIDER

Type:	Primary glider
Accommodation:	1 pilot
Span:	32 ft 10 in
Wing area:	165 sq ft
Empty weight:	175 lb
Gross weight:	375 lb
Cruising speed:	25 mph

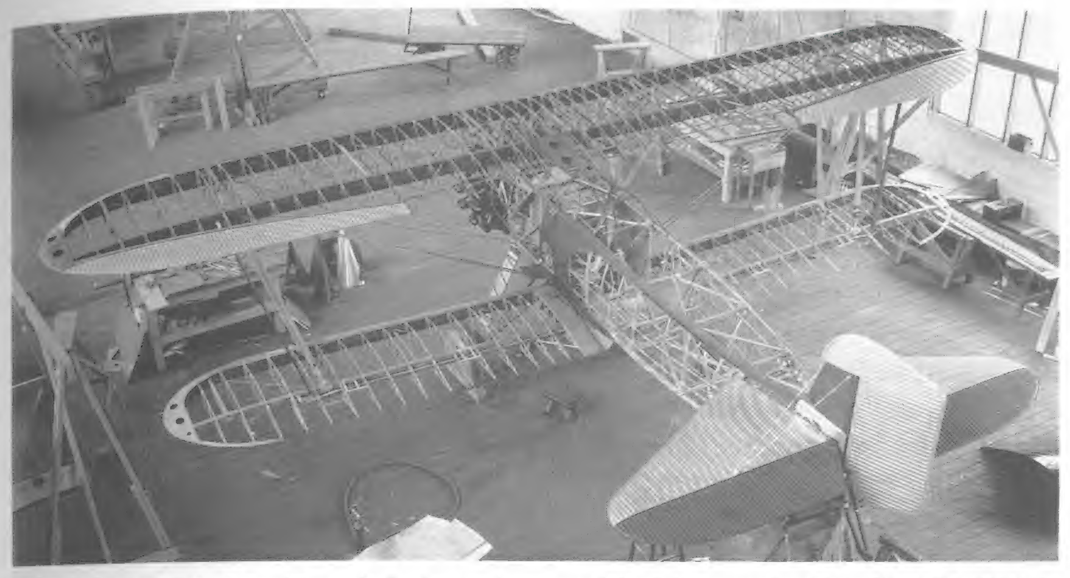
Chapter 5

THE FAMOUS FIGHTER FAMILY

June 25, 1928, saw the first flight of a new Boeing fighter, the Model 83, which had been developed at company expense in the hope of providing a successor to the Army PW-9s and Navy F2Bs and F3Bs then in service. The risk of bringing out a new model for the highly competitive military market without the benefit of firm commitments in the form of a development contract was justified, however, for the Model 83 and its sister ship, the Model 89, became the prototypes of one of the best-known fighter series of the between-wars years. Altogether, 586 aeroplanes of the P-12/F4B/100 series were built, including export models with other designations. They brought the era of the biplane fighter to an end for the Army, and were in service in secondary roles for both the Army and Navy until shortly after the US entry into WW-II.

There was nothing really new about the new design, except the model number, and this was one of the major reasons for its success. It incorporated all of the experience that the company had gained in the preceding seven years of fighter design and construction (Chapter 3) and used only conservative and thoroughly-tested features. The great improvement in performance over earlier models powered with the same Pratt & Whitney Wasp engine was the result of detail refinement and more efficient application of the various features already developed.

Boeing Model 83, prototype of the famous biplane fighter family, photographed in civil colours at the San Diego Naval Air Station during tests in July 1928. (*Courtesy Harry Gann*)



Wooden wings, bolted aluminium tube fuselage, and corrugated aluminium control surfaces of P-12 (Model 102) show clearly in this uncovered view. Tapered ailerons are peculiar to F4B-1 (Models 83, 89, 99), Model 100 and 100A, and P-12 (Model 102) only. (*Boeing Photo P-2334-B*)

Another reason for the success of the new model was the fortunate timing of its appearance. Although the biplane design was on the decline in civil aviation at the time, military requirements for fighters and other tactical types still demanded biplanes following the patterns of WW-I designs. Experimental monoplane fighters began to appear in the Army in 1930 and in the Navy in 1933, but another four to six years were to elapse in each case before production aircraft were delivered for service use. The P-12/F4B/100 series found ready acceptance in a market that it had been specifically developed to meet and did not suffer the disadvantage of being either too advanced to be acceptable, as was the case of some later models, or too late and at the tail end of a dying design series that was rapidly being replaced by more modern types.

The relatively long production life of the basic model and its gradual growth and refinement through the production and modification of successive models makes a perfect textbook example of evolution in the art of aeroplane design and shows the full life cycle of a 'family' of aeroplanes. Because of this, the P-12/F4B/100 series is presented in a chapter by itself and out of sequence with other Boeing model sequence or chronology.

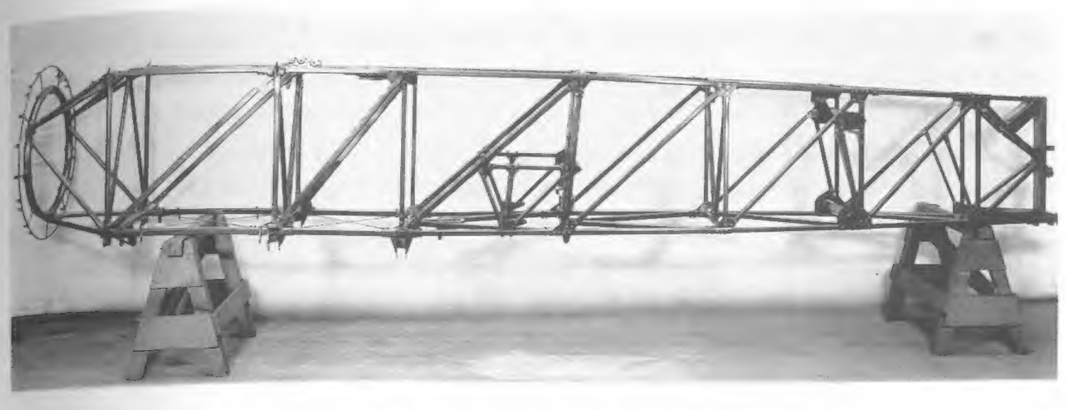
Some of the changes made to the basic design were the result of experience with earlier models of the series that showed a need for improvement, some features were adapted from experimental models of other series that were not placed in production, and some were 'retrofit' installations where the components of late models were used on earlier models in place of the original parts. Some of these changes were initiated by Boeing or the services to improve the effectiveness of the design as a fighting aircraft. Others, especially some made by the Army Air Corps, were merely for the purpose of developing or service testing power plant or equipment features with general aircraft applications. In such cases, the

aeroplanes were frequently given experimental designations and a new series letter to indicate their change from standard fighter status and to protect the test programme from the time losses incurred in mandatory compliance with the Technical Orders (maintenance bulletins) that were issued from time to time against most standard service aircraft. Redesignating a P-12B as XP-12G, for example, freed the aeroplane from the requirements of a bulletin issued to improve the combat effectiveness of all P-12Bs. The new designation did not indicate a new or late-model experimental prototype in this case. The aeroplane was still a basic P-12, but since the P-12F designation had already been assigned to later fighters then on order, the next higher series letter was used to distinguish the variation. When the experimental equipment was removed at the end of the turbo-supercharger test programme, the XP-12G reverted to its original status of P-12B and was redesignated as such. Because of such conversions, full performance figures are not given for every different designation appearing in the P-12/F4B/100 series.

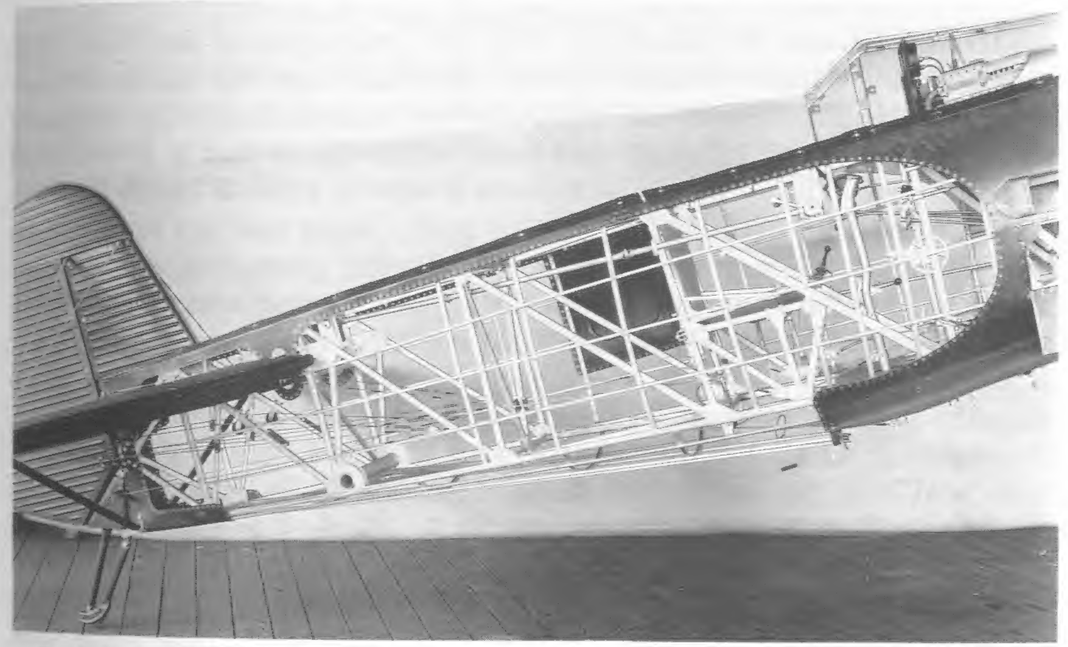
Outwardly, the major difference between the Model 83 and earlier Boeing fighters was the use of straight instead of tapered wings. Wing construction was the same; two box spars with spruce flanges and 3-ply mahogany ribs. The ribs were bandsawed from plywood and fitted with spruce capstrips. The upper wing was in one piece as on previous models, but the two lower wings, although built separately, were bolted together at the spar butts for installation as a single unit. The tail surface and ailerons were of semi-monocoque corrugated dural construction. The fuselage of the Model 83 and the early production models of the series was a unique composite – welded steel tubing in the centre section-engine area and bolted square dural tubing from the cockpit aft. Bolted instead of welded joints had been used for fuselages of earlier fighter models, notably the F2B-1, when both steel and aluminium tubes were bolted directly to one another through dural gussets in the manner of the Model 80A. The 80A had an earlier designation than the Model 83/89 but was actually a later aeroplane, so the new fighters were actually the first Boeings to use the new type of construction.

The armament of all models of the series built for the US armed forces followed the prevailing standard, one ·30 calibre machine gun to the left of the centre line and one ·50 calibre on the right, and bombs could be carried

P-12s were not used to equip a secret German Air Force in the early 1930s; P-12Cs were flown by Air Corps pilots during the making of the WW-I air-war film *Hell Below* in 1933. (Courtesy Paul Laudan)



Bolted square-section aluminium tubing fuselage structure of the US Army P-12B, similar to that used on all fighters from Model 83 to the Model 227/P-12D. (*Boeing Photo 3502-B*)



Fuselage of a P-12 after addition of superstructure. Note sheet metal strips with eyelets, used to lace on fabric in areas where it does not wrap fully around the fuselage. Tube crossing fuselage above lower longeron is for insertion of lifting bar used when tailskid was manually hoisted onto a wheeled dolly to facilitate ground handling. (*Boeing Photo 2450-B*)

Three P-12Es in extemely tight line-abreast formation. This type of precision flying by military aerobatic teams disappeared at the end of the biplane fighter era and did not reappear until the advent of jets after WW-II. (*USAF Photo 13672-AC*)

on racks under each lower wing or on the fuselage. A 55 gal auxiliary fuel tank could be fitted under the belly as optional equipment. Other items of equipment varied with changing military or customer requirements. While the F4Bs were a dual-purpose design, both fighter and dive bomber, all were designated as fighters even though some were delivered to bomber squadrons since the BF designation for Bomber-Fighter did not exist at the time the F4B was in production.

Direct performance comparisons between different models of the P-12/F4B/100 series cannot be made even though all used the same basic P & W R-1340 engine because various series of the engine delivered their maximum power at different altitudes and the designated mission of the aircraft also varied.

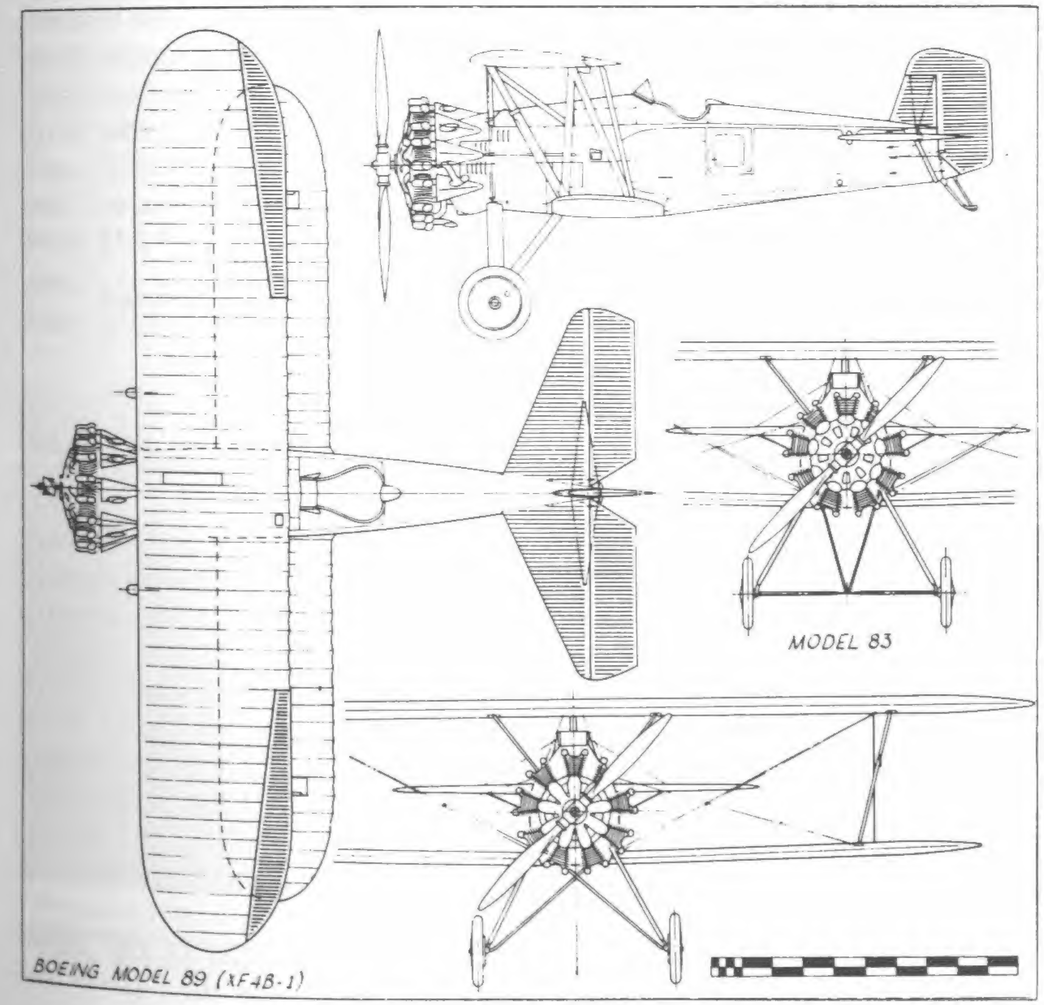
MODELS 83 and 89 (XF4B-1) – The two prototypes of the P-12/F4B series, Boeing Models 83 and 89, were identical except for undercarriage and minor details. The 83 had a spreader-bar undercarriage with diagonal strut bracing to the spreader mid-point while the 89 had a full tripod undercarriage. The 89 was provided with a rack for a 500 lb bomb and the 83 was fitted with deck-landing arrester gear. Colour schemes for the two were identical, silver predominating, with Boeing green trim on fuselage and tail and International orange on the top of the upper wing. Since both aeroplanes were Boeing-owned, they did not carry military markings, but, strangely, neither did they carry the civil registrations that had been assigned to them. Although not Navy property, the Navy referred to both aeroplanes as XF4B-1 in official paperwork and the 83 did carry the words U.S. NAVY in the standard aft fuselage location while under test in civil colouring at San Diego, California.

The Model 83 first flew on June 25, 1928, and was delivered to the Navy at San Diego on June 28 after preliminary evaluation at the Sand Point Naval Air Station, Seattle. The Model 89 was sent by rail to the Navy Test

First prototype XF4B-1 (Model 83) with experimental long-nose Wasp engine and cross-axle landing gear. Test flight made at Sand Point Naval Air Station, Seattle. (*Courtesy Mike Pavone*)

Divided landing gear legs on second prototype XF4B-1 (Model 89) permitted carriage of 500 lb bomb under belly. No arrester hook fitted to this aircraft. (*Boeing Photo P-2076*)

Centre at Anacostia, Maryland, on July 24 and made its first flight on August 7. While at Anacostia, this aeroplane was loaned to the Army and was tested by Army pilots at Bolling Field, the Army installation across the airfield from the Navy Anacostia installation.



Both models were originally fitted with special long nose versions of the Pratt & Whitney R-1340B engine, which was supposed to improve the streamlining at the nose of the aeroplane. These were soon replaced by the standard versions with only a 1 mph decrease in top speed. The difference was not considered sufficient to justify production of the special engine.

Both were returned to the factory at the completion of military testing for modification to production F4B-1 configuration and were purchased as plain F4B-1s. They were given Navy serial numbers immediately ahead of those on the F4B-1 contract, and while identified as F4B-1 were sometimes referred to in subsequent Navy documentation as XF4B-1 because of external details that still distinguished them from the production versions.

TECHNICAL DATA - MODEL 83/89

Type:	Fighter
Accommodation:	1 pilot
Power plant:	P & W R-1340B Wasp 450 hp
Span:	30 ft
Length:	20 ft 7⅜ in
Height:	9 ft 7¼ in
Wing area:	227·5 sq ft
Empty weight:	1,664·8 lb
Gross weight:	2,557 lb
Max speed:	168·8 mph
Cruising speed:	142 mph at 60% power
Climb:	2,920 ft/min
Service ceiling:	26,900 ft
Range:	520 miles
Armament:	One ·50 cal MG, one ·30 cal MG, one 500 lb bomb (Model 89)

C/ns	*Registrations*	*Navy serial numbers*
1039 (Model 83)	NX7133	8129
1040 (Model 89)	NX7134	8128

MODEL 99 (F4B-1, F4B-1A) - Twenty-seven production F4B-1s were ordered as a result of Navy testing of the two prototypes, and incorporated the undercarriage and bomb provisions of the Model 89 and the arrester hook of the Model 83. The first F4B-1 flew on May 6, 1929, and all were delivered between June 19 and August 22. Colouring was all silver except for chrome yellow on the top surface of the upper wing. Some were delivered with the vertical Navy rudder striping while others had silver-coloured rudders. While only 27 production F4B-1s were built, not enough to equip two full squadrons (18 aeroplanes), they were delivered in two different squadrons, some as bombers to VB-1B and the remainder as fighters to VF-2B.

No ring cowling was fitted originally, but each cylinder of the radial engine had an individual streamlined fairing behind it. After the F4B-1s had

The first XF4B-1 (Model 83) reworked to production configuration and delivered to the Navy as the second article on the F4B-1 (Model 99) contract. Revised landing gear configuration shown was peculiar to this one machine (Navy Serial No. 8129) only. Metal parts were painted silver. (*Boeing Photo P-2475-B*)

been in service for a short while, tests proved that removal of the fairings not only improved cylinder cooling but increased the maximum speed of the aeroplane by 3 mph. They were ordered removed from all F4B-1s in service. Still later, ring cowlings were added, as were later Model F4B-4 vertical fins. Gross weight of the F4B-1 increased over the prototypes to 2,724 lb and the top speed dropped to 166·3 mph. Unit costs less engines and GFE were $13,750.

C/ns:	1110/1136
Navy serial numbers:	A-8130/8156

Production F4B-1 in early markings. Metal parts were painted grey following a change in Navy colouring specifications. Note individual fairings for engine cylinders. Use of two-wheel dolly was common practice for ground movement of tailskid aeroplanes. Very few US Navy Fighters carried rudder stripes between 1926 and the adoption of camouflage in 1941. (*Photo by William T Larkins*)

F4B-1s relegated to training schools in their later years and fitted with Townend anti-drag rings around the engines and the larger F4B-4 vertical fin in June 1933. (*Courtesy James Mathiesen*)

• F4B-1A – One F4B-1, Navy serial number 8133, was modified as a special executive aeroplane for David S Ingalls, then Assistant Secretary of the Navy and the Navy's only WW-I ace. This special model was stripped of armament, fitted with a ring cowl, and painted with the special blue fuselage colouring of Naval Executive aircraft. The installation of the fuel tank in the centre section of the upper wing in the manner of the two-seat Boeing Model 100A indicates that this machine may have been intended as a two-seater, but no Boeing or Navy records confirm this.

The fourth production F4B-1 completed as a special administrative transport for the Assistant Secretary of the Navy for Air under the designation of F4B-1A. Note Secretary's flag and dark blue fuselage colouring typical of aircraft assigned to VIPs (*US Navy Photo*)

The second Model 100, commercial equivalent of the Navy F4B-1 and the Army P-12. This machine was delivered to Pratt & Whitney as a flying engine test bed. (*Boeing Photo P-2514-B*)

MODEL 100 – Four Model 100s were built as commerical/export versions of the F4B-1. The principal differences were the deletion of standard US military equipment and the installation of the fuel tank in the centre section of the upper wing. Although essentially military airframes, the Model 100s were fully licensed under ATC 133. This was issued on April 1, 1929, two months before the first Model 100 flew. P-12 engineering and test data were used to qualify the civil model as the only designed-for-the-purpose fighter ever to receive a full ATC for licensed civil operations.

The first Model 100 (c/n 1142) was delivered to the Bureau of Air Commerce (now Federal Aviation Agency, or FAA) on June 7, 1929, with the government-owned short aircraft registration NS21. Price less government-furnished equipment was $13,500.

The second Model 100 as modified by stunt pilot Milo Burcham with low-pressure tyres, filled-in landing gear legs, and metal side panels for the fuselage. (*Photo from A U Schmidt Collection*)

The second Model 100, acquired in damaged condition by Paul Mantz for his stable of motion picture aircraft, reassembled and modified to resemble a two-seat Curtiss F8C-2 Helldiver for the film *Task Force*, circa 1950. (*Photo by Lee Enich*)

The second, NX872H (c/n 1143), was sold to Pratt & Whitney for use as a flying test bed. In addition to the original P & W R-1340 Wasp, this aircraft flew with the R-985 Wasp Jr, the R-1535 Twin Wasp Jr, and the R-1690 Hornet engines. Original colouring was French grey with Boeing Green trim and International orange on the upper wing surface. It was then sold to stunt pilot Milo Burcham, who used it in air show work from 1933 to WW-II, with distinctive modifications and red, blue and silver colouring as NC872H. The space between the undercarriage vees was faired in, low-pressure Goodyear airwheels were substituted for the regular high-pressure 28 × 4 in tyres, and the fuselage side fabric was replaced with metal panels. The remains of this aeroplane were still owned by Tallmantz Aviation Co of Santa Ana, California, in 1964. After being sold at auction in 1968 the aeroplane was mostly rebuilt by its new owner. It was then sold to Boeing Chief Test Pilot Lew Wallick and his partner Robert Mucklestone. It was then completed and flown, with a P & W Wasp Jr engine, painted as a P-12 of the 95th Pursuit Squadron, the first US Army unit to use the P-12. In 1986 the second Boeing Model 100 was donated to the Museum of Flight in Seattle, Washington.

The third 100, c/n 1144, has had the most varied career and has carried every possible arrangement of US civil registration number starting with plain 873H through C, NC, NR, NX and finally N873H. With the standard Boeing colouring of its immediate predecessor, it was used at the factory for several years as a test vehicle and demonstrator, and was then sent to the Boeing School of Aeronautics at Oakland, California, for use as an advanced trainer. It was acquired about 1936 by Paul Mantz for air show work and still used for such purposes into the 1970s. After WW-II the original P & W Wasp engine was replaced by a war-surplus 450 hp P & W R-985 Wasp Jr. Painted as an F4B-1 of the Navy 'Red Rippers' Squadron VF-5B, it was

The third Model 100, obtained by Paul Mantz from Boeing School of Aeronautics and used almost continually for motion picture and TV work from 1936 to 1965. Here shown with smaller P & W Wasp Jr engine, low-pressure tyres, and smoke generating equipment. (*Photo by Warren M Bodie*)

sold to the Weeks Aviation Museum in Miami in 1985.

The fourth 100, NX 874H (c/n 1145), was used as a factory demonstrator and test model in Boeing colours and was eventually sold to the Mitsui Co of Japan.

MODEL 100A – This was a special convertible two-seat version of the basic Model 100 built to the special order of Mr Howard Hughes and was licensed under Memo 2-83. A second cockpit without controls was installed forward of the normal cockpit in the location used for armament and fuel tanks on the P-12/F4B series, and the fuel was carried in two 25 gal tanks in the centre section of the upper wing and in a single 40-gal fuselage tank. First flight and delivery took place on July 25, 1929. Original colouring was the standard Army olive drab fuselage with chrome yellow wings and tail.

The single Boeing Model 100A, delivered as a two-seater with an extra cockpit installed ahead of the main cockpit. This cockpit was extremely cramped, and was seldom used, usually being covered over. (*Boeing Photo P-2555-B*)

Extensive modifications were performed on the Model 100A by first owner Howard Hughes. (*Photo from A U Schmidt Collection*)

The Model 100A had a long and almost continuous career of nearly 30 years. Hughes undertook extensive modifications after taking delivery, added a full NACA cowl, wheel pants, and a higher vertical tail. Performance changes resulting from these modifications are unknown. The aeroplane was later sold to Col Arthur Goebel for air show work as a single-seater, and passed through the hands of several successive owners. An early postwar modification was the installation of a single-strut PT-17-type undercarriage and metal-skinning of the fuselage. The last noticeable modification before destruction of the aeroplane in 1957 was the reduction in size of the vertical tail and the use of a triangular vertical fin.

C/n: 1094
Registration: 247K

Final form of the Model 100A after ownership by a succession of professional air show pilots shortly before its demise in 1957. (*Photo by Bryan Baker*)

The fourth Model 100 modified to demonstrate improved features and designated 100D. (*US Navy Photo courtesy The Boeing Co*)

MODEL 100D – No aeroplane was built under this designation, which was temporarily assigned to the Model 100 demonstrator NX874H (c/n 1145) during a 1931 sales programme intended to sell an export version corresponding to the contemporary Army P-12D (Model 227). While using such P-12D features as ring cowl, undercarriage, and internal equipment, the 100D retained the basic 100 wing with tapered ailerons and centre section fuel tank.

MODEL 100E – The two Model 100Es built for Thailand were export versions of the P-12E then in production for the US Army but could not be given the same Boeing designation of Model 234 (page 184) because of government restrictions on the export of aircraft currently in production for US Services. Consequently, the basic commercial/export designation of Model 100 was applied with the suffix E added to indicate general structural, equipment, and performance similarity to the P-12E.

The single Model 100F delivered to Pratt & Whitney as a flying test bed after installation of geared twin-row R-1535 engine. Large propeller diameter made take-offs and landings in a three-point attitude mandatory. (*Photo courtesy Harvey Lippincott*)

Both 100Es were delivered on November 10, 1931, without having been assembled, flown, or photographed at the factory. The last surviving example, taken over by the Japanese during WW-II, is in the Thai Aeronautical Museum at Bangkok.

C/ns: 1487, 1488

MODEL 100F – The Model 100F was a commercial equivalent of the Army P-12F, delivered to Pratt & Whitney as a flying engine test bed. The standard R-1340 Wasp was replaced at the Pratt & Whitney factory by a 700 hp R-1535 Twin Wasp Jr and the aeroplane was first flown with that power plant on June 20, 1932. The higher power and lowered propeller speed of this geared engine required a propeller of unusually large diameter for an aircraft of this design, and take-offs and landing with the Model 100F when fitted with this engine could only be made in the three-point attitude.

Like P & W's first Model 100, NX872H, the 100F also flew with the P & W Hornet in addition to the Wasp and Twin Wasp Jr, but the remarkable fact is that it once flew with each of the separate engines on the same day during a demonstration of quick engine-changing techniques.

Because of the different engine weights, the balance of the aeroplane was corrected during these engine changes by use of a sliding weight installed in the fuselage between the cockpit and the tail. On a high-altitude test flight the pilot became unconscious when his oxygen supply failed. The 100F fell into a spin, and the weight, which was not designed to resist such gyrations, broke loose and destroyed the controls, making recovery from the spin impossible.

C/n: 1681
Registration: X-10696

The XP-12A (Model 101), the tenth machine of the original P-12 order, extensively modified to test new features, several of which were used on later models. (*Boeing Photo P-2419-B*)

MODEL 101 (XP-12A) – The XP-12A was the last article on a contract for ten P-12s ordered as a result of Army testing of the second XF4B-1 (Model 89) but carried an earlier Boeing Model number than the P-12 (Model 102).

The XP-12A differed considerably from the production P-12 in being fitted with Frise-type ailerons having the hinge lines parallel to the wing spar instead of at an angle as on the F4B-1, P-12, 100 and 100A; shorter undercarriage; full engine cowl of Boeing design; redesigned elevators; and a castoring tail skid. The full effect of these improvements could not be properly evaluated because the aeroplane was destroyed in a mid-air collision with a P-12 at Wright Field on May 18, 1929, after only 4 hr of flight time. First flight was on April 11, 1929, and the aeroplane was shipped to Wright Field on April 26.

Provision was made for the standard P-12/F4B-1 installation of one ·50 calibre and one ·30 calibre machine gun or two ·30 calibre machine guns, and five 25 lb bombs.

C/n: 1109
Army serial number: 29-362

MODEL 102 (P-12) – Ten Army equivalents of the F4B-1 were ordered following Army testing of the XF4B-1/Model 89 at Bolling Field, and nine were completed as standard fighters. The first P-12 built was turned over to Air Corps Captain Ira C Eaker on February 26, 1929, shortly after his famous 150 hr endurance flight. In special colouring and devoid of military markings, this P-12 was named *Pan American* and used for a goodwill speed flight to Central America before being returned to the factory for conversion to standard configuration on April 26, 1929. The first flight of a standard serivce P-12 was on April 11, 1929, after several had already been shipped to

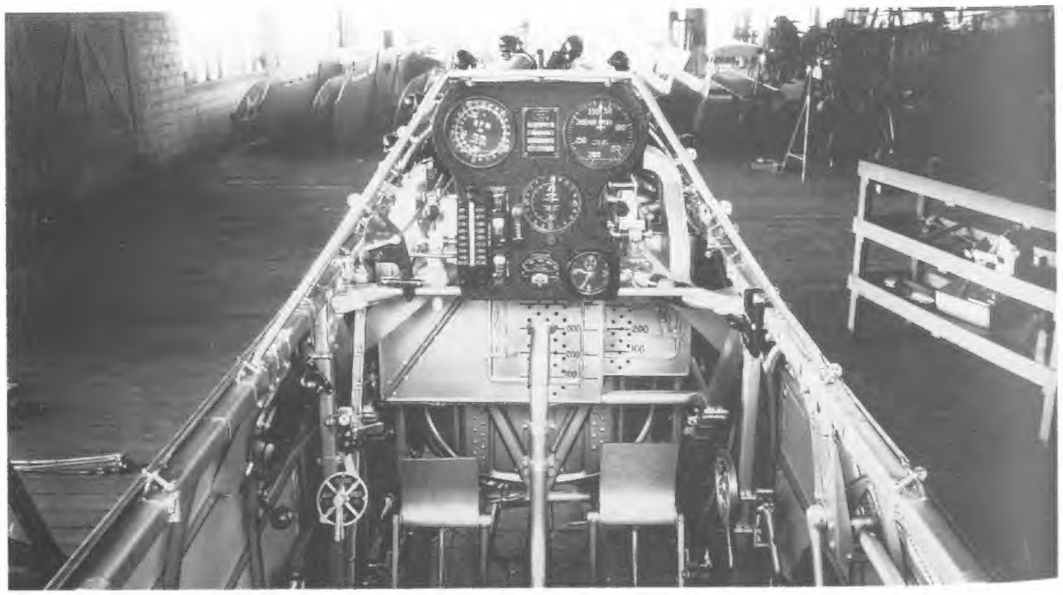
The first Army P-12, with special colour scheme, delivered in advance of the standard models for a special Army goodwill flight to Central America. Comparative size of pilot Capt Ira Eaker shows that by 1929 single-seat fighters were no longer 'tiny' aircraft. (*Boeing Photo P-2327-B*)

P-12B (Model 102B), incorporating improved ailerons and elevators developed on the XP-12A. Compare with P-12 and Model 100 photos on pages 163 and 171. Note camera gun on upper wing. (*Wright Field Photo 39020*)

the Army. The last P-12 was delivered on April 26, 1929. Colouring was standard Air Corps olive drab for fuselage, struts and wheels, and chrome yellow for wings and tail.

The basic P-12 was the only model in the Army series to use the tapered ailerons of the earlier F4B-1s and 100s and can be distinguished from the later P-12B by this feature alone. P-12s were delivered with the individual engine cylinder fairings developed on the Model 83/89, but these were later deleted following the example of the Navy F4B-1s.

C/ns: 1100/1108
Army serial numbers: 29-353/361



Cockpit of a US Army P-12B. Note large-face instruments, including vertical-scale power plant instruments at left of panel, Boeing nameplate at top of panel, and ammunition boxes replacing drums. (*Boeing Photo 3497-B*)

The first P-12B, modified by the Army as XP-12G to test turbo-superchargers and ring cowlings. Notice use of three-blade propeller to absorb the additional power. (*USAF Wright Field Photo 42791*)

MODEL 102B (P-12B, XP-12G) – The P-12B was a slightly improved P-12, and the first of the P-12 series to be built in true production quantities. One was diverted from squadron use for an engine test programme under the designation of XP-12G.

• P-12B – The P-12B could be distinguished outwardly from the P-12 by the Frise ailerons and revised elevators of the XP-12A and the use of slightly larger 30 × 5 in wheels instead of the earlier 28 × 4 in model. The undercarriage and uncowled engine were the same as the P-12 except that the original streamline cylinder fairings were not used. Ring cowlings were added later to some P-12Bs. Ninety P-12Bs were ordered on June 10, 1929, at a cost of $11,224 each less engines and GFE. The P-12B first flew on May 12, 1930, and the last was delivered on May 17, rail delivery of dismantled aircraft having begun on February 1, 1930.

C/ns: 1170/1259
Army serial numbers: 29-329/341, 29-433/450, 30-29/87

• XP-12G – The first P-12B was converted by the Army to XP-12G by installation of experimental P & W Y1SR-1340G and H engines fitted with turbo-superchargers and ring cowlings of the type adopted for the P-12C. Upon completion of the engine testing the aeroplane reverted to P-12B.

MODEL 218 (XP-925, 925A) – The Model 218 was a Boeing-owned aeroplane used to test new features for the P-12/F4B series. It was tested by both the Army and the Navy under Bailment Contract, and can be considered as the prototype of both the P-12E and the F4B-3.

The Model 218 first flew on September 29, 1930, and was essentially a P-12B with semi-monocoque metal fuselage structure similar to the XP-9, XP-15, and XF5B-1 (Models 96, 202, and 205).

Original form of the Model 218, which introduced a new monocoque metal fuselage structure to the established F4B/P-12 line and served as the prototype for both the P-12E and the F4B-3. (*Boeing Photo*)

The shape of the vertical tail surfaces was changed early in the test programme from P-12B type to the form used on the modified XP-15/XF5B-1 design. The experimental Army designation of XP-925 was assigned during testing with the R-1340D engine and was changed to XP-925A when an R-1340E was installed. Empty weight increased to 1,954 lb, gross weight was 2,694 lb, and the speed with the altitude-rated R-1340D engine was 195 mph at 8,000 ft.

The Model 218 was sold to China after US testing, and, flown by American Volunteer Pilot Robert Short, is reported to have destroyed two out of three attacking Japanese fighters before being shot down over Shanghai in 1932.

C/n: 1260
Registration: X-66W

Later form of the Model 218 during Navy testing. Note the revised rudder shape and the temporary use of wheel 'pants' installed in an attempt to obtain additional speed. (*US Navy Photo 461136*)

MODEL 222 (P-12C) – The P-12C was an improved P-12B with a later engine and minor refinements. The most noticeable external changes were the use of a ring cowl and a spreader-bar undercarriage similar to that of the Model 218 and the original Model 83. The initial P-12C order, placed on June 2, 1930, was for 131 aircraft, but the last 35 were completed as P-12D. Delivery of disassembled P-12Cs to the Army began on August 30, 1930, and the last was delivered on February 12, 1931. The first recorded flight of a P-12C was on January 30, 1931. After a period of service, 16 P-12Cs were converted to P-12D (which see).

C/ns: 1262/1344, 1346/1358
Army serial numbers: 31-147/242

MODEL 223 (F4B-2) – The F4B-2 was an improved F4B-1 and was the naval equivalent of the Army P-12C (Model 222), the principal outward difference from the F4B-1 being the addition of spreader-bar undercarriage, ring cowl, Frise ailerons, and a tail wheel. Price less engine and GFE was almost identical to the P-12C and D, $10,800 compared to $10,644 for the Army models.

The first F4B-2 was delivered on January 2, 1931, and the last on May 2. The colouring differed slightly from the F4B-1s as delivered in that metal parts were painted light grey instead of silver. All F4B-2s, along with the F4B-1s were, eventually fitted with the later F4B-4 vertical tail surfaces by a Technical Order issued late in 1932.

C/ns: 1392/1418, 1439/1457
Navy serial numbers: 8613/8639, 8791/8809

MODEL 227 (P-12D, XP-12H) – The P-12Ds were obtained by slightly modifying the last 35 of the original 131 aircraft P-12C order, but outwardly the Ds were identical to the Cs. Slight differences in cowling contour were common to both the P-12C and D and could not be used as a recognition feature. Identification was possible from the front, however; on the P-12D the ignition harness was on the front of the engine instead of behind it as on the P-12C and the cowling support struts visible on the P-12C were not used. Both models were later fitted with P-12E vertical tails by the Army. Deliveries began on February 25, 1931, and were completed on April 28, with the first flight being made on March 2.

C/ns: 1261, 1345, 1359/1391
Army serial numbers: 31-243/277
From P-12C: 31-152/154, 156, 157, 159/161, 175, 195, 209/212, 233, 234

• XP-12H – The 33rd P-12D was redesignated XP-12H when the Army fitted it with an experimental geared P & W GISR-1340E engine. Tests proved the engine unsatisfactory and the aeroplane was reconverted to a P-12D in June 1932.

C/n: 1387 *Army serial number:* 31-273

P-12C (Model 222), first of the production F4B/P-12 models to use a ring cowl. Note readoption of the cross-axle landing gear of Model 83, which was developed further on the fourth Model 100 and the Model 218. (*Courtesy Museum of Flight*)

F4B-2 (Model 223), essentially a naval duplicate of the Army P-12C. Compare the position of the pivoted cross-axle on this airborne F4B-2 with that of the P-12C, which is carrying the full weight of the aircraft on the ground. (*US Navy Photo*)

P-12Ds (Model 227) in the colourful markings of the 34th Pursuit Squadron, circa 1931. (*Courtesy Boardman C Reed*)

Standard P-12D fitted with vertical tail surfaces of the later P-12E. Compare the reversed colour values of the tail stripes taken with panchromatic film to those of the XP-12A picture on page 176, taken with orthochromatic film. (*Photo by John C Mitchell*)

The XP-12H, the third-from-last P-12D redesignated by the Army when used to test a special geared version of the standard P & W Wasp engine. Note P-12E tail. (*USAF Wright Field Photo 41789*)

The single P-12J was P-12E 32-42 modified to test a supercharged engine and a new bomb sight, and soon reverted to P-12E. Note the enlarged 'Panama' headrest containing a life raft. (*Photo by Gordon S Williams*)

MODEL 234 (P-12E, P-12J, YP-12K, XP-12L, A-5, F4B-4A) – The Model 234, ordered by the Army as P-12E, was the first production model of the P-12/F4B series to use the new fuselage and tail surfaces of the Model 218. Other components were essentially those of the P-12D. A contract for 135 P-12Es, costing $10,197 each less GFE, was signed on March 3, 1931, and 110 were delivered as such between September 19 and October 15, 1931. The last 25 were converted to P-12F before completion. First flight of a P-12E was on October 15, 1931. Empty weight was 2,013 lb, gross weight was 2,701 lb, and top speed was 189 mph at 7,000 feet.

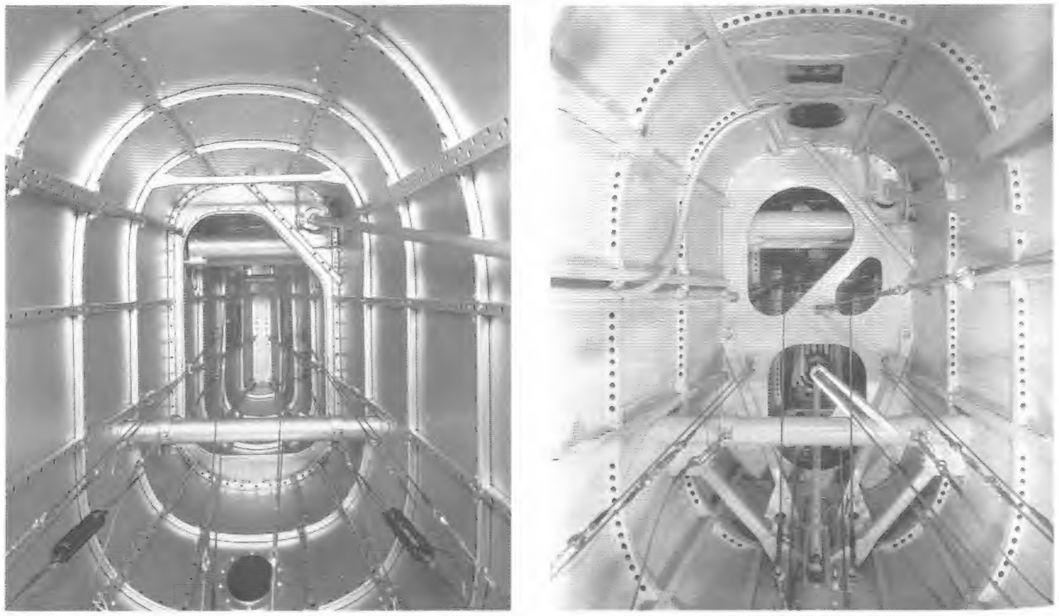
The P-12Es were built with flotation gear in the upper wing as on previous models, but this feature was deleted and replaced by a rubber life raft for the pilot stored in an enlarged 'Panama' headrest, so called because it was developed for use in that area.

As originally delivered, P-12Es and Fs were painted with the standard Army olive drab fuselage and yellow wings and tail. The fuselage colouring was later changed to Air Corps blue, and in 1940 the entire aeroplane was painted silver under an Air Corps directive calling for all tactical types having painted surfaces to be repainted in this colour.

C/ns: 1460/1486, 1489/1533, 1535/1572
Army serial numbers: 31-553/586, 32-1/76

The basic P-12E underwent many changes of designation after entering service, as listed below, without change of the Boeing model number. The changes had little effect on overall performance.

• XP-12E – The first P-12E was redesignated XP-12E on October 1, 1931, immediately after delivery. This did not distinguish it as the prototype



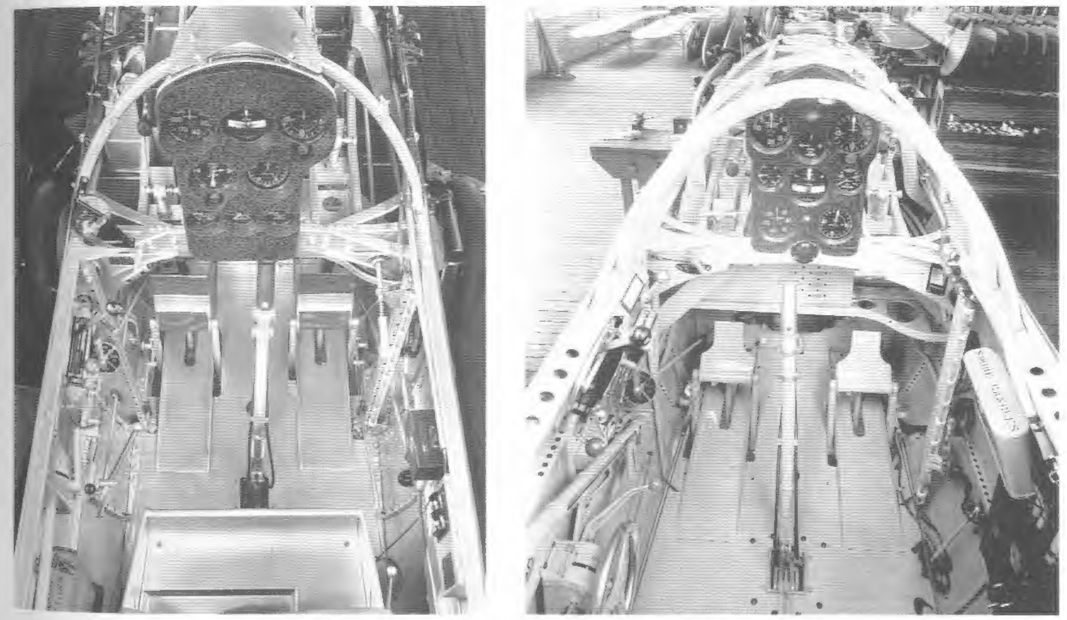
Interior views of rear fuselage of P-12E (left) and F4B-4 (right) showing the structural differences resulting from different specifications of the two Services. The formers and longerons of the P-12E are square-section aluminium tubing while corresponding components of the F4B-4 are top-hat sections pressed from sheet aluminium. (*Boeing Photos 4842-B and 5652-B*)

P-12E, but merely identified a basic E withdrawn from regular service for test work. After several other changes of designation (see below), 31-553 was reconverted to a standard P-12E.

• P-12J – P-12E 32-42 was redesignated P-12J when a P & W SR-1340H engine, rated at 575 hp at 2,500 feet, and a special bomb sight were installed at Wright Field. This aeroplane became one of the seven YP-12Ks after still another engine change.

• YP-12K – The XP-12E, P-12J, and five standard P-12Es (32–33, 36, 40, 46, and 49) became YP-12K when SR-1340E engines with fuel injection were installed for service test. All YP-12Ks reverted to P-12E in June 1938.

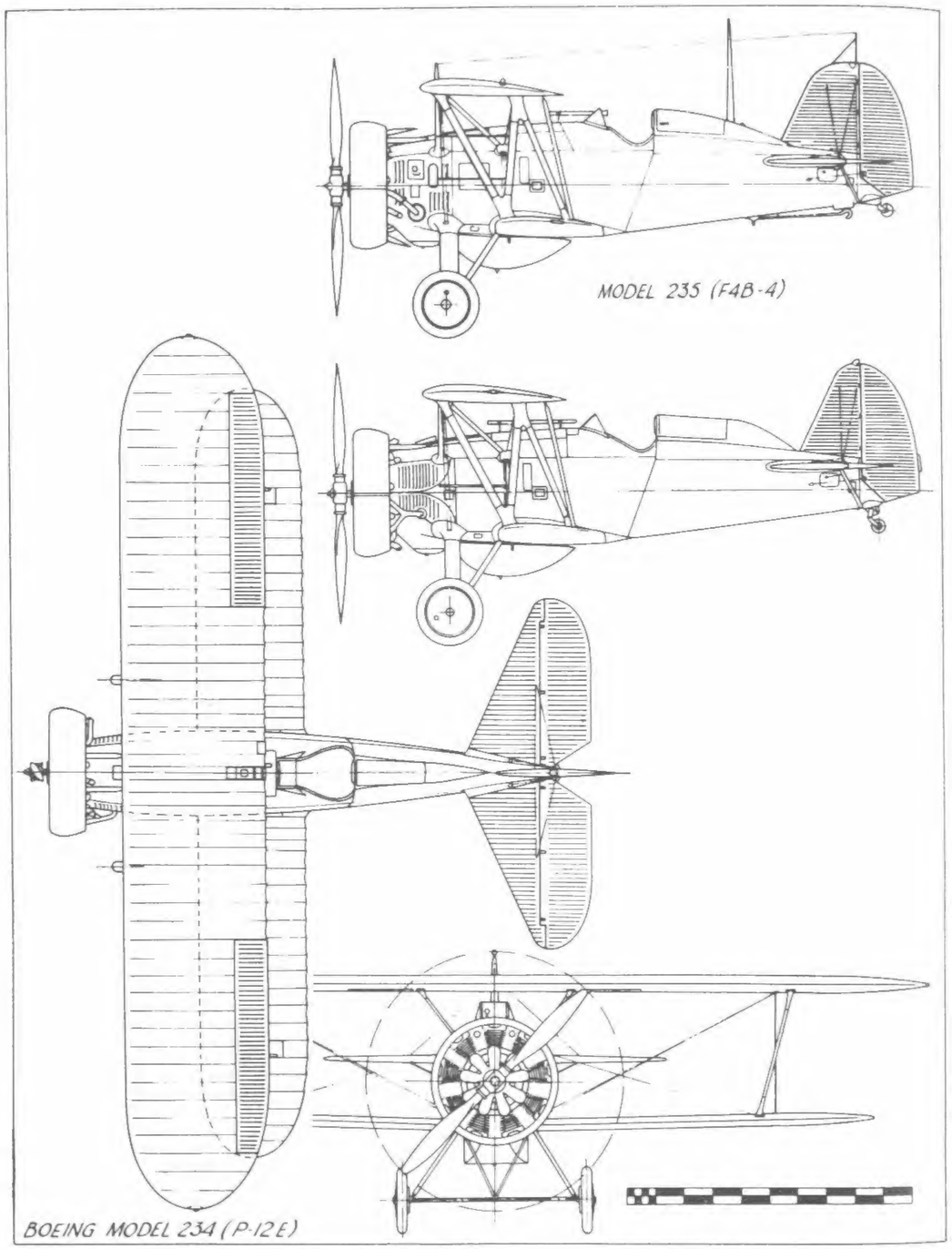
• XP-12L – YP-12K 31-553 (ex-XP-12E) was redesignated XP-12L on January 2, 1934, when fitted with a Type F-7 turbo-supercharger. It reverted to YP-12K in February 1937, and became P-12E with the rest of the YP-12Ks in June 1938.



Comparative views of P-12E cockpit (left) and F4B-4 cockpit (right) showing entirely different instrument layouts, magneto switch locations, and even different rudder pedal shapes. (*Boeing Photos 4862-B and 5653-B*)

• A-5 – One P-12E was to have been fitted with radio controls in 1940 and tested as an unmanned target aeroplane. The Army abandoned the practice of using obsolete service models for this purpose at the time and the A-5 did not materialize.

• CIVIL P-12E – One of the obsolete P-12Es (32–17) given to civilian schools in 1940–41 as non-flying classroom equipment was obtained by the Planes of Fame Museum from the California Polytechnic Institute. It was slowly restored to display condition and was made flyable in 1961. The civil registration number N3360G was assigned. Repainted as an F4B-3, it



participated in Navy celebrations of Armed Forces Day the same year. In 1962, it was restored to Army configuration as a P-12E. It is now based at the Museum's new facilities at Chino Airport, California.

Another former ground school P-12E (31-559), woefully incomplete, was acquired by another private owner and was donated by the US Air Force Museum. It has now been rebuilt and is on display at the Wright Field facility in the markings of the 6th Pursuit Squadron that it once carried.

One of seven YP-12Ks, P-12Es redesignated while testing fuel injection engines, fitted with the combination ski-wheels that were widely used by the Air Corps in the 1930s. (*Photo by Gordon S Williams*)

MODEL 235 (F4B-3, F4B-4) – The F4B-3 was the naval production model of the 218, and duplicated the Army P-12E except for equipment and minor structural differences in the cockpit area. The F4B-4 was identical except for a large vertical fin on all, and a life raft stowed in an enlarged streamlined headrest on the last 45 built, but these minor changes did not justify the use of a different Boeing model number. Empty weight rose to 2,185 lb and gross weight became 2,899 lb for the fighter and 3,361 lb for the bomber version.

• F4B-3 – Twenty-one F4B-3s were ordered on April 23, 1931. The first was delivered on December 24, 1931, and the order was completed on January

The P-12E, owned by the Planes of Fame Museum of Chino, California, painted in Navy colours to represent an F4B-3 during the commemoration of the 50th Anniversary of US Naval Aviation in 1961. (*E M Sommerich Collection*)

An F4B-3 (Model 235) carrying the special colours used by the US Marine Corps for air show participation in 1935. (*Courtesy Boardman C Reed*)

20, 1932. Because of its all-metal fuselage, this part of the F4B-3 was painted light grey all over, as were all other metal parts except the tail surfaces, which were given a solid colour to correspond to the current Naval colour-coding of various carrier-based aircraft groups. Application of these colours to aeroplanes at the factory was not common, but was carried out on F4B-3s destined for Squadron VF-1B. F4B-3s transferred to the US Marine Corps used the older arrangement of vertical red, white, and blue tail stripes with chrome yellow on the upper surface of the horizontal tail.

C/ns: 1595/1615
Navy serial numbers: 8891/8911

• F4B-4 – The 92 F4B-4s were ordered at the same time as the F4B-3s, but delivery was delayed until July 21, 1932, because the Navy had allowed the

An F4B-4, distinguishable from the near-duplicate F4B-3 only by the enlarged vertical fin. Aircraft 3-F-7 shown, based on aircraft carrier *Ranger* in 1935, has tail stowed on a boom that projects overboard to conserve deck storage space. (*US Navy Photo*)

first 14 on order to be modified and diverted to Brazil as Boeing Model 256. The last of the replacement airframes was delivered on February 28, 1933. Seventy of the F4B-4s were delivered to the Navy and 21 went to the Marine Corps. After service with Squadron VMF-10 on the West Coast, the Marine models were transferred to VMF-9 at Quantico, Virginia, where they received non-standard markings, including the solid-colour tails that were common to Navy practice at the time. One additional F4B-4 (9719) was produced without a Boeing factory serial number, assembled by the Marine Corps from spare parts supplied with the original order.

The US Marines operated their F4B-4s from land bases, with the deck arrester gear removed. However, pilots and their assigned aircraft were required to qualify for deck landings, and on such occasions the arrester gear was reinstalled.

C/ns: 1616/1624, 1626/1634, 1636, 1640, 1642/1655, 1659, 1666/1670, 1742/1793
Navy serial numbers: 8912/8920, 9009/9053, 9226/9263, plus 9719 (See Appendix VI for actual Navy serial number–c/n correlations.)

• F4B-4A – While most P-12Es and Fs were grounded and assigned to Air Corps and contract mechanics' schools in 1941, 23 miscellaneous P-12s were turned over to the Navy in 1940 for use as radio controlled target aircraft on the A-5 pattern. Although carrying different Army series designations, all of these P-12s were given the same designation of F4B-4A by the Navy, the A identifying their former Army status.

The majority of the obsolete F4B-4s were expended as radio-controlled target drones in 1941–42. Test pilots could ride in modified cockpits. (*Courtesy Earl Vivell*)

The Navy serial numbers were 2489/2511 in the second series while equivalent Army serial numbers (and Army designations) were:
P-12C 31-151, 154, 209, 210
P-12D 31-245, 258
P-12E 31-561, 564, 576, 32-10, 13, 25, 33, 40, 41, 44, 46, 48, 57, 66, 69, 71
P-12F 32-85

• Civil F4B-4s – Two Marine Corps F4B-4s (Navy Nos. 9241 and 9251) were stripped of military and deck-landing equipment and turned over to the Bureau of Air Commerce, now FAA, in 1940. While these were government-owned aeroplanes, entitled to carry the special NS registration number prefix, they were registered NC-13 nd NC-14 under Memo 2-555. Registration numbers lower than the NS-21 of the Bureau's earlier Boeing Model 100 resulted from the fact that the Bureau reserved low numbers for its own use and reassigned them as the aeroplanes were replaced.

One of the two F4B-4s that survived WW-II under civil ownership. This extensively modified model was destroyed in 1948. (*Photo by Peter M Bowers*)

Both F4B-4s were soon released by the government and sold to stunt pilot Jesse Bristow, who used one for air show work until 1947. The former NC-14 (Navy No. 9251) received a new registration, NR-9846, and was extensively modified by Bristow to incorporate a later 600 hp P & W Wasp with controllable pitch propeller, new I struts, revised undercarriage, a full NACA cowling around the engine, and fittings under the belly for two JATO rocket-propellant bottles. The combination of the JATO bottles, higher-powered engine, and controllable propeller permitted spectacular near-vertical take-offs at air shows. This extensively modified F4B-4 was destroyed in 1948 in a crash by a new owner.

The other F4B-4, formerly NC-13 (Navy No. 9241) with new registration NR-9329, retained its standard outward appearance in the hands of several new owners and at one time was fitted with crop-spraying equipment. It

The last surviving F4B-4, restored in non-flyable status by the former Naval Aircraft factory for exhibition during the 50th anniversary of naval aviation in 1961. (*Photo by Warren D Shipp*)

was eventually donated to the Smithsonian Institution, and the former Naval Aircraft Factory at the Philadelphia Navy Yard was prevailed upon to restore it to its original military configuration and colouring for display in the National Air Museum. The job was rushed to completion in time for Armed Forces Day and the 50th anniversary of US naval aviation in May 1961. Later, the last of the F4B-4s was repainted in the exact colouring and markings that it had carried in Marine Squadron VFM-9 and is now installed in the National Air and Space Museum in Washington, D.C.

MODEL 251 (P-12F) – The last 25 aeroplanes on the original P-12E order (Model 234) were completed as P-12F. The initial difference was the installation of an SR-1340G engine that delivered its 500 hp at 11,000 ft instead of the 7,000 ft for the SR-1340E in the P-12E. The last ten P-12Fs

The last of twenty-five P-12Fs built was fitted with an experimental enclosed cockpit canopy. (*USAF Wright Field Photo 48706*)

A P-12F (Model 251) in the all-silver painted finish applied to certain formerly blue-and-yellow US Army Air Corps aeroplanes in 1940. The P-12F, 32-89 (c/n 1584), salvaged from a buried dump, was being restored to flying condition in 1987. (*Photo by O R Phillips*)

were the first P-12s delivered with tail wheels, although the earlier Fs and all the Es later had tail wheels installed by retrofit.

The last P-12F, 32-101, gave a preview of future trends in fighter configuration by having a closed cockpit canopy installed at the factory. This aeroplane was also the last of the P-12 series, all designations higher than P-12F being conversions of earlier models. Although carrying a later Boeing model number than the F4B-4 (Model 235), the P-12F was an earlier aircraft, with delivery starting on March 6, 1932, and ending on May 17. Colouring and subsequent history of the P-12F was identical to that of the P-12E.

C/ns: 1534, 1573/1594, 1676, 1677
Army serial numbers: 32-77/101

MODEL 256 ('1932') – Fourteen of the original F4B-4s were diverted from the Navy order and modified slightly for delivery to Brazil as land-based fighters. Deletion of the arrester gear, flotation equipment, US Navy radio

The two Model 256s at the left were US Navy F4B-4s released to Brazil while the three Model 267s at the right were combination P-12E/F4B-3s built to Brazilian order. (*Bowers Collection*)

and armament, and other minor modifications resulted in the new Boeing model number of 256, which was called '1932' by the Sales Department to identify the export model as an up-to-date design. The first was delivered on September 14, 1932, and the last on October 8.

C/ns: 1635, 1637/1639, 1641, 1656/1658, 1660/1665

MODEL 267 – The Brazilian order for 14 modified F4B-4s known as '1932' (Model 256) was followed by another order for nine similar types known as Model 267, which used the F4B-3 fuselage, tail, and landing gear, and P-12E wings. The entire order was delivered on February 21, 1933, a few days before delivery of the last F4B-4, which the 267 order followed. The serial numbers indicate that the 9th Model 267 was not only the last of the 586 aeroplanes in the P-12/F4B series, but, disregarding the two Model 203As built at the Boeing School of Aeronautics in 1935–37 and the former Stearman models built in Wichita to the end of WW-II, was also the last biplane built by Boeing.

C/ns: 1794/1802

Chapter 6

NEW CONCEPTS

The years between 1919 and 1929 can be regarded as the post-World War I era of aviation in that the concepts of aircraft design and structure developed during the war years dominated the thinking of government and private users of aeroplanes and resulted in a decade of designs so conservative that they were little more than refinements of the standard types developed between 1914 and 1918. While many new and really advanced designs had appeared during WW-I and during the following decade, they were either unacceptable to potential customers or the state of the art had not developed to the point where their advanced features could be used with maximum efficiency or be produced economically. The tried-and-true designs prevailed.

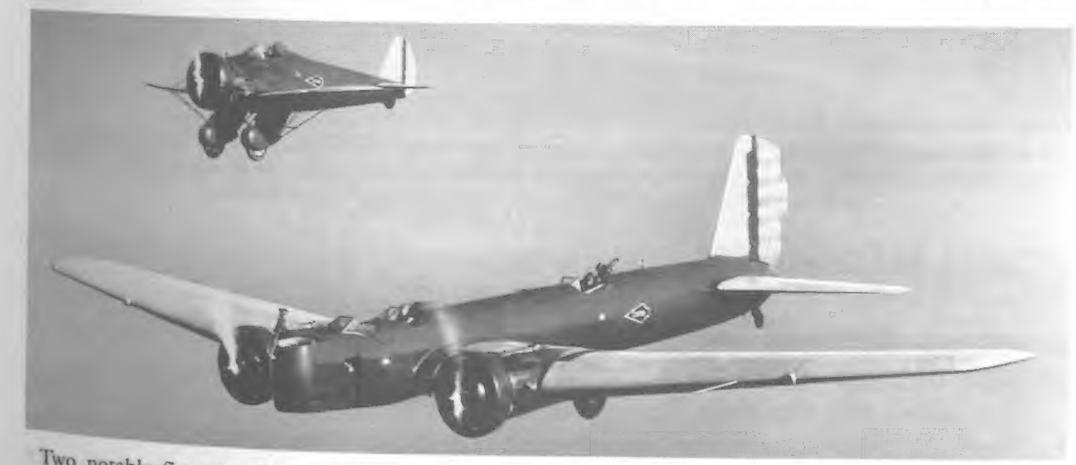
The first major break with traditional design took place in the commercial field, where the dollar advantage of the monoplane over an equivalent biplane model made sense to hard-headed businessmen. Trimotor monoplanes entered airline service in 1926 and single-engine monoplanes were used for mail and passenger work. The greater efficiency of the monoplane was proved over and over again with the rash of distance and duration flights that followed Lindbergh's nonstop flight from New York to Paris in May 1927. While the manufacturers who were mainly in the commercial field rushed to design new monoplanes, Boeing and other large suppliers of military aircraft stuck to biplane design during the closing years of the postwar period because the Army and Navy still specified biplanes for practically all military purposes. Because of this military preoccupation with the biplane, the new era began later for some manufacturers than for others.

For Boeing, it began on May 29, 1929, when the Army signed a contract calling for the design of an experimental fighter monoplane of all-metal construction to be known as the XP-9. While this aeroplane was thoroughly conventional in many ways it marked a significant milestone for the company in that it opened up new paths of development and encouraged original designs along lines that had not previously been acceptable to the principal buyers of Boeing products. In keeping with sound technical and business practice, the change to new concepts of design and construction was not made rapidly. Designs then in production were constantly being improved, and new features used for the first time on the purely experimental XP-9 were gradually introduced into the later production versions of the older designs until they were phased out. All of the really new designs, those initiated after the appearance of the XP-9 instead of

Plant 2, built across the Seattle–Tacoma highway from Boeing Field for production of the Y1B-17s and assembly of the XB-15. Present-day employees wish that their parking problems could be as simple. (*Photo by Gordon S Williams*)

being developments of earlier designs, followed the new concept of the all-metal monoplane and were quick to adopt such new features as retractable undercarriages, the latest NACA cowlings, controllable-pitch propellers, and the various items of advanced equipment that distinguished the new era from the postwar period.

Throughout most of this period, which continued until the outbreak of WW-II, the company changed but little in plant size and personnel in spite of the soundness of the new designs. Continued existence of an aircraft manufacturer in the acute economic depression years of 1929-1933, when dozens of small concerns went bankrupt, was in itself a mark of success. Boeing production facilities remained at the wartime shipyard site on the Duwamish River, but flight operations were brought closer to home when Boeing Field, the King County Airport, was opened at the southern limits of Seattle in 1928. The company maintained a small assembly and



Two notable firsts in Air Corps history – the Boeing XP-936, prototype of the Army's first production monoplane fighter, and one of the Boeing Y1B-9As, service test model of the Army's first all-metal cantilever monoplane bomber. (*USAF Photo*)

operations building there, but soon rented a large brick hangar from the county for use as a final assembly area for airframes trucked to the field from the factory two miles away.

Not until 1936, when the B-17 went into production (see Chapter 8), did the company undertake any appreciable expansion of its manufacturing facilities. Land was acquired on the west side of Boeing Field and a new factory, known as Plant 2, was built there. The XB-15 bomber, built at Plant 1, was the first aeroplane assembled at Plant 2, and the production B-17s and all subsequent production models except the Model 314 flying-boats were built there. The only aeroplanes built at Plant 1 after the 314s were experimental prototypes. The King County hangar at Boeing Field was retained as a test facility, and was referred to generally as 'the B-17 Hangar' until diverted to other purposes in 1960 because the Model 299, prototype of the B-17 series, had been assembled there in 1935.

The new era saw a major change take place in Boeing's position in the industry as well as changes in the design details of its products. Where the company's reputation in the post-WW-I era was based largely on its position as the major source of fighter aircraft, it withdrew from the fighter business in 1936 and established an entirely new reputation for the remainder of the pre-WW-II period as the major manufacturer of four-engine bombers.

The XP-9 (Boeing Model 96) was designed as a result of early Army Air Corps interest in new monoplane fighters. Photographed in the factory with a white cloth background before shipment to Wright Field. Note original small corrugated metal fin and rudder. (*Boeing Photo 4004-B*)

MODEL 96 (XP-9) – Model 96 was the company designation assigned to a fighter designed to Army Specification X-1623A on May 24, 1928, and designated XP-9 by the Army when a contract for its design and construction was signed with Boeing on May 29, 1928.

The XP-9 was the first Boeing monoplane to start through the factory, but various delays postponed its scheduled delivery date from April 1929, to September 1930, so it was not the first to fly, having been beaten into the air by the new Model 200 Monomail (page 198) and the 202/205 fighters (see

Early test flights of the XP-9 at Wright Field revealed a need for increased vertical tail area. This was provided by the new tube-and-fabric structure shown. (*USAF Wright Field Photo 39434*)

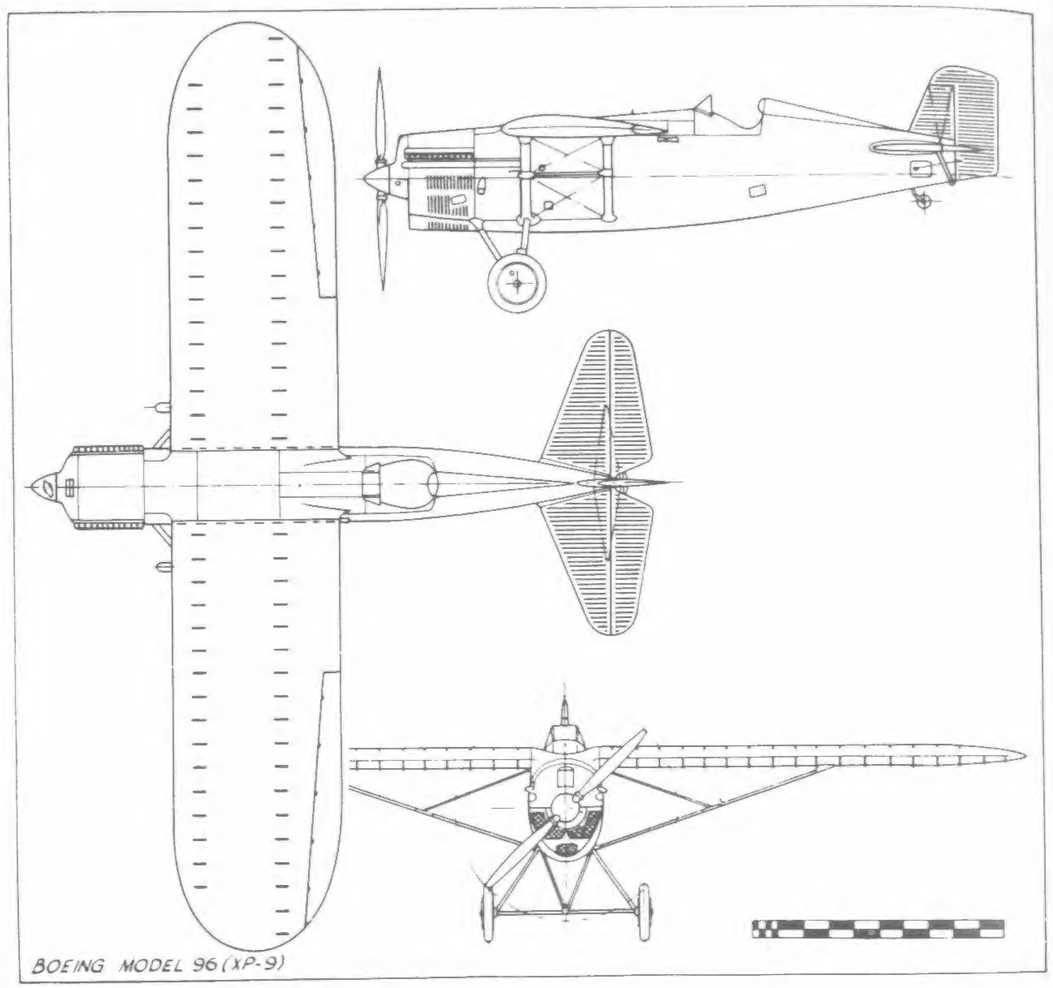
Chapter 4). The construction of the XP-9 was entirely new to Boeing practice, and both the 200 and the 202/205 designs drew heavily on it. The fuselage was the most advanced feature, using a semi-monocoque structure of sheet dural over metal formers for that portion aft of the rear undercarriage struts and welded steel tubing from that point forward to the engine. The original tail surfaces were identical to those of the P-12/F4B, and the conventional two-spar wing used metal framework with fabric covering. The general proportions were those of the P-12/F4B cut down to a high-wing monoplane.

The XP-9 was not test flown in Seattle as was customary, but flew on November 18, 1930, after delivery by rail to the Army Test Centre at Wright Field. The XP-9 did not come up to expectations even though control was improved by replacement of the P-12 vertical tail with a larger design, and an option for five YIP-9 monoplanes to be built under the P-12D contract was not exercised.

The XP-9 was relegated to use as a non-flying instructional airframe in August 1931, after accumulating only 15 flying hours.

TECHNICAL DATA – XP-9

Type:	Fighter	*Max speed:*	213 mph
Accommodation:	1 pilot	*Cruising speed:*	180 mph at 60% power
Power plant:	Curtiss SV-15700 600 hp at 2,400 rpm at 12,000 ft	*Climb:*	1,560 ft/min
Span:	36 ft 6 in	*Service ceiling:*	26,800 ft
Length:	25 ft 1¾ in	*Range:*	425 miles
Height:	9 ft 10¼ in	*Armament:*	Two ·50 cal MG two 122 lb bombs, five 25 lb bombs
Wing area:	210 sq ft		
Empty weight:	2,669 lb		
Gross weight:	3,623 lb		
C/n:	1045		
Army serial number:	28-386		



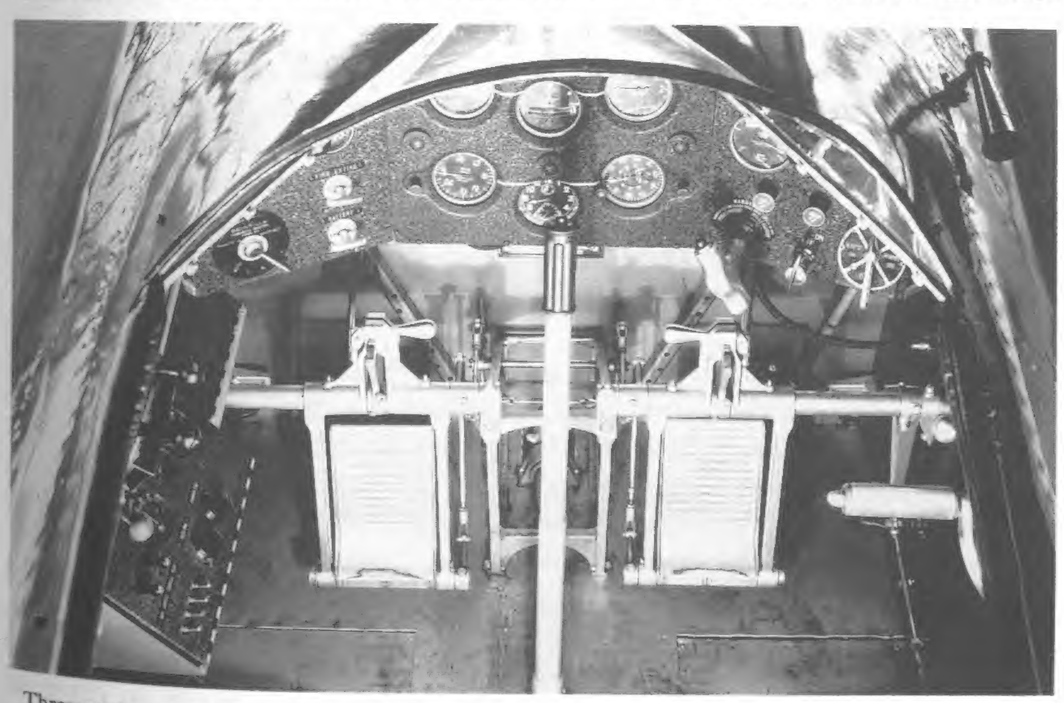
MODEL 200 (MONOMAIL) - The Model 200, named Monomail by Boeing, was a combined mail/cargo carrier that used the same engine as the Model 40B but showed a great performance increase over the classic biplane. Aerodynamic refinement resulting from the change to a monoplane design was not enough; extra performance was obtained through such refinements as adding an anti-drag ring to the radial engine and retracting the undercarriage backward into the wing until only half of each wheel protruded into the airstream. Additional streamlining was obtained through the use of cantilever construction of the all-metal wing, eliminating the need for struts and wires. The use of a semi-monocoque metal fuselage permitted the use of a more nearly circular cross-section and hence a further improvement in streamlining.

While the fuselage construction was based somewhat on that of the XP-9, the tail surfaces used smooth skins instead of the corrugated surface adopted for the F3B-1 and subsequent fighters and the Model 95 mailplane. The wing construction owed much to the Model 80A. The two main spars were built up of square-section dural tubing riveted together in the form of Warren truss girders, and were joined by additional Warren truss ribs that supported upper and lower sheets of corrugated dural which in turn

The structural and aerodynamic features of the Model 200, a single-seat mail/cargo monoplane, named Monomail, were major milestones in the history of Boeing aeroplane designs. (*Boeing Photo P-22151*)

supported the external smooth wing skins between the spars. The nose section skins were attached directly to conventional nose ribs secured to the front spar and the ribs aft of the rear spar were likewise attached directly to the wing skin.

While the Monomail was almost a radical design by the aerodynamic and structural standards of the years that immediately preceded it, it was also an outstanding example of the basic conservatism of the aviation industry. For all its new features, the Monomail followed the long-established pattern of the standard single-engine mailplane - cargo and mail compartment located in the fuselage at the centre of gravity and the pilot in an open cockpit behind the wing, just as in the de Havillands of 1920. The new design also pointed out another reason for conservatism - the need to wait for the state



Three-section angled instrument panel of Model 200 Monomail had detailed resemblance to Model 95 installation. Note new electrical control panel on left side. (*Boeing Photo 3846-B*)

of the art to develop to the point where the advanced features of new designs could be supported by the proper equipment necessary to assure their efficient use. Much of the potential speed advantage of the Monomail that resulted from its advanced streamlining was lost because ground adjustable propellers set to fly the aeroplane at high speed would barely enable it to take off with an appreciable payload at a sea level airport, much less any of the high-altitude fields along the transcontinental route. Not until controllable-pitch propellers came into general use a few years after the Monomail appeared could the full potential of the advanced design be utilized.

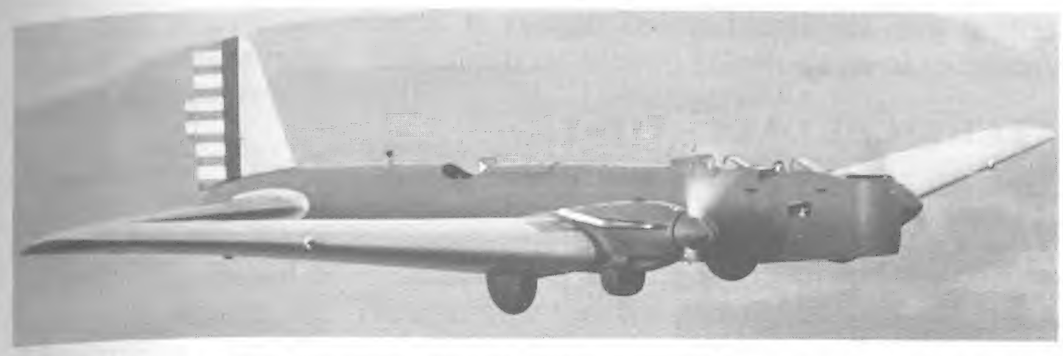
The original colouring of the Monomail at the time of its first flight, May 6, 1930, was green fuselage, grey tail with green outline, and grey and orange wings with the orange applied to a curved area starting at the leading edge near the fuselage and reaching full chord at the tips. Later, when the original Model 200 was converted to a passenger-carrying Model 221A and placed in service on the Cheyenne–Chicago route of United Air Lines, it used a natural metal finish. In its mailplane configuration, the Model 200 carried ATC 330.

TECHNICAL DATA - MODEL 200 MONOMAIL

Type:	Mailplane
Accommodation:	1 pilot, 220 cu ft of cargo and mail
Power plant:	P & W Hornet B, 575 hp at 1,950 rpm
Span:	59 ft 1½ in
Length:	41 ft 2·47 in
Wing area:	535 sq ft
Empty weight:	4,758 lb
Gross weight:	8,000 lb
Max speed:	158 mph
Cruising speed:	135 mph at 60% power
Climb:	850 ft/min
Service ceiling:	14,000 ft
Range:	530 miles
C/n:	1153
Registration:	NX (later NC) 725W

MODEL 214 (Y1B-9) - Models 214 and 215 were new bomber designs that applied the aerodynamic and structural concepts of the Model 200 Monomail to equivalent advances in another field traditionally dominated by the biplane. Both were developed at Boeing expense and differed only in engine installation. Model 215, powered with two Pratt & Whitney Hornet engines, was completed first.

Like the Monomail, the new bomber introduced daring new structural and aerodynamic concepts while retaining traditional arrangements. As in all bombers since WW-I the internal bomb bay was located in the fuselage at the centre of gravity and additional bombs could be hung on external wing racks.



Model 214 was the first of two company-financed bomber prototypes but was the second to fly. It was designated Y1B-9 after purchase by the Army Air Corps. Note projecting rudder servo tab. (*USAF Photo*)

The bombardier/nose-gunner occupied a cockpit in the nose, which was equipped with a bomb sight and aiming window at the bottom and a mount for a flexible machine gun around the top. Because of the narrowness of the fuselage, the pilot and co-pilot occupied tandem cockpits immediately behind the bombardier instead of sitting side-by-side in a single wide cockpit. A radio station was located ahead of and below them in the fuselage, and a fourth cockpit for a rear gunner was located on top of the fuselage behind the wing. In spite of the great advance in speed over contemporary bombers, all cockpits of the Model 214/215 were open.

Because of the increased loads on the movable control surfaces at the higher speeds of the B-9, rudder servo tabs were installed for the first time on an American aeroplane to use aerodynamic forces to assist the pilots in moving the controls. On Model 214 the tab was a small auxiliary surface projecting aft of the rudder trailing edge. On Model 215 it was a tall narrow surface running the full height of the rudder trailing edge.

Model 214, originally powered with the 600 hp Prestone-cooled Curtiss GIV-1510C engine, was completed as a military aeroplane because favourable testing of Model 215, which had been completed first, resulted in the signing of an Army contract for the purchase of both aeroplanes on August 14, 1931, before the second one had flown. Model 215 was designated YB-9 at the time of purchase and Model 214 was designated Y1B-9. The Y1B-9 made its first flight on November 5, 1931, and after

Model 215, differing from Model 214 by use of radial engines, was designated XB-901 by the Army during early test flights and became YB-9 after purchase. (*Boeing Photo P-4522-B*)

testing with the liquid-cooled engines at Seattle and Wright Field, was converted to an air-cooled installation duplicating that of the 215/YB-9.

TECHNICAL DATA - Y1B-9

Type:	High-speed bomber
Accommodation:	5 crew
Power plant:	Curtiss GIV-1570 600 hp at 2,450 rpm
Span:	76 ft
Length:	56 ft
Wing area:	932 sq ft
Empty weight:	8,574 lb
Gross weight:	13,608 lb
Max speed:	173·5 mph
Cruising speed:	147·5 mph at 60% power
Climb:	900 ft/min
Service ceiling:	19,200 ft
Range:	1,250 miles
Armament:	Four ·30 cal MG, two 1,100 lb bombs
C/n:	1458
Army serial number:	32-302

MODEL 215 (XB-901, YB-9) – The Model 215 was a near duplicate of the Model 214, but was completed and flown first. Developed at company expense, it carried civil colour and markings at the time of its first flight, April 13, 1931. It was tested by the Army as Boeing property on a Bailment contract under the designation XB-901. The basic aeroplane design was given the standard Army bomber designation of B-9 when purchased later in the year, and the prefix Y was added to indicate service test status. The aeroplane was then repainted in military colours and the civil registration was cancelled.

While the B-9s are generally recognized as the aeroplanes that revolutionized bomber design, they were not the first monoplane bombers developed for the US Army. They were preceded by the Douglas B-7 series and the General Aviation (Fokker) XB-8. While both of these designs featured retractable undercarriages, their design concept was older than the B-9, both aerodynamically and structurally. Initial Army enthusiasm following the appearance of the XB-901 brought unofficial assurance of sizeable production orders, and Boeing believed that its pioneering efforts would be profitable. However, the risks involved in pioneering in a highly competitive industry soon became apparent when the Glenn L Martin Company brought out a private design of its own that was tested by the Army as the XB-907. It was a slightly later design than the XB-901 and had better performance, winning the large production orders under the designations of B-10 and B-12 that Boeing had expected would be awarded to the B-9. Performance of the 215/YB-9 was essentially that of the 214/Y1B-9 and the dimensions were identical.

C/n:	1459
Civil registration:	X-10633
Army serial numbers:	32-301

MODEL 221 – Model 221 was also named Monomail and duplicated the original Model 200 except that the fuselage was 8 in longer and a cabin was provided that could accommodate six passengers separately from the 750 lb of mail. The second Monomail flew on August 18, 1930, and was soon in service on Boeing Air Transport routes. No production versions of the Monomail were built.

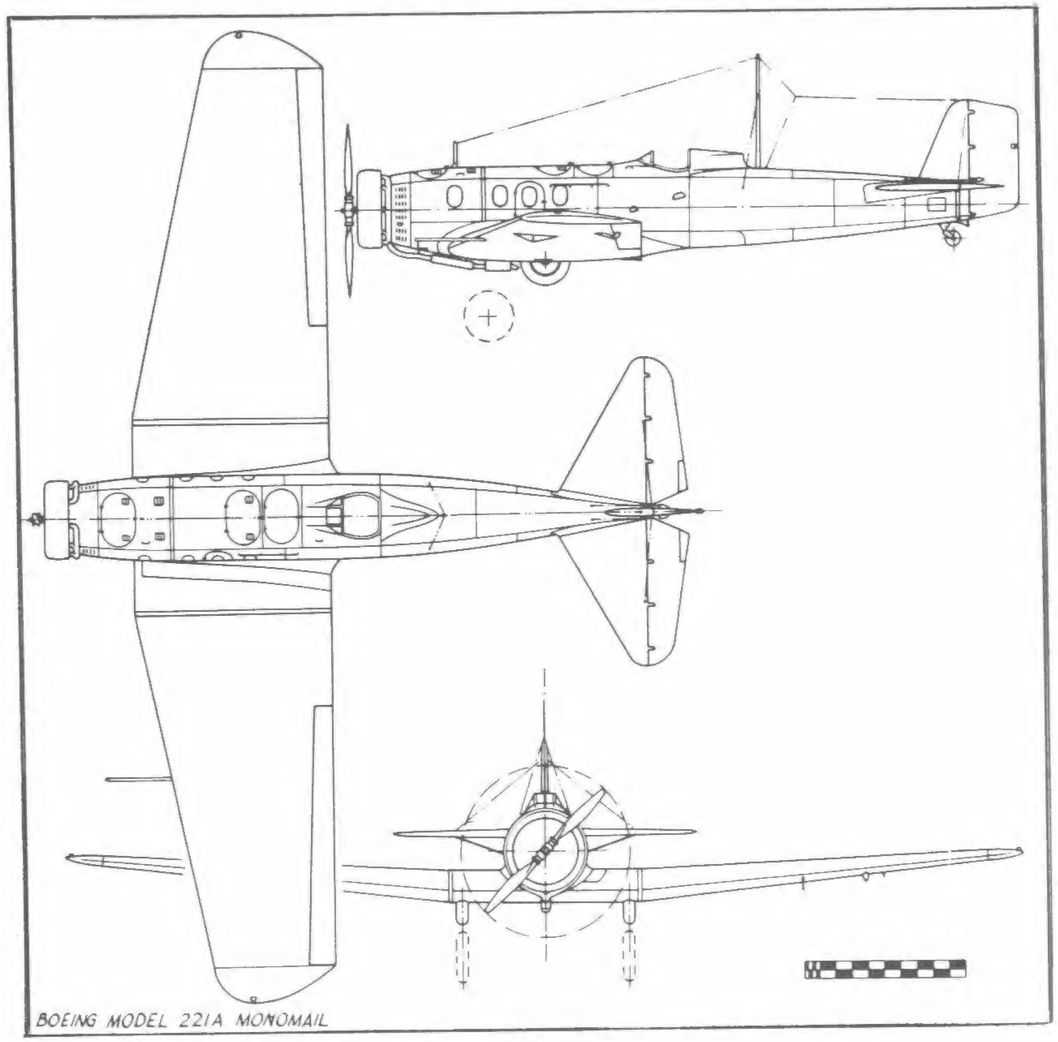
C/n:	1154
Registration:	NC-10225

The original Model 200 Monomail, modified to a passenger-carrying Model 221A, is shown here during evaluation of a streamlined non-retractable landing gear. (*Boeing Photo*)

• 221A – Seating capacity of the Model 221 was increased to eight when the fuselage was lengthened 27 in to permit the installation of two additional seats. The single-seat Model 200 was modified to the eight-passenger configuration and both operated on the BAT routes under ATC 347. For a while, the converted Model 200 was used for experimental test work at the factory. One test programme evaluated a carefully streamlined fixed undercarriage against the established retractable type. A more significant contribution was made, however, through evaluation of trailing edge tabs for the elevators, which greatly simplified the longitudinal trim correction problem. Current practice was to mechanically alter the setting of the entire

The second Monomail, Model 221, was built with a six-passenger cabin. The fuselage was later lengthened as shown to carry two additional passengers and the aeroplane became Model 221A. Insignia identifies Boeing Air Transport Division of the original United Air Lines. (*A U Schmidt Collection*)

horizontal stabilizer. The use of trim tabs, later supplemented by booster or servo tabs, remained standard for most subsequent aircraft until the appearance of jets after WW-II.



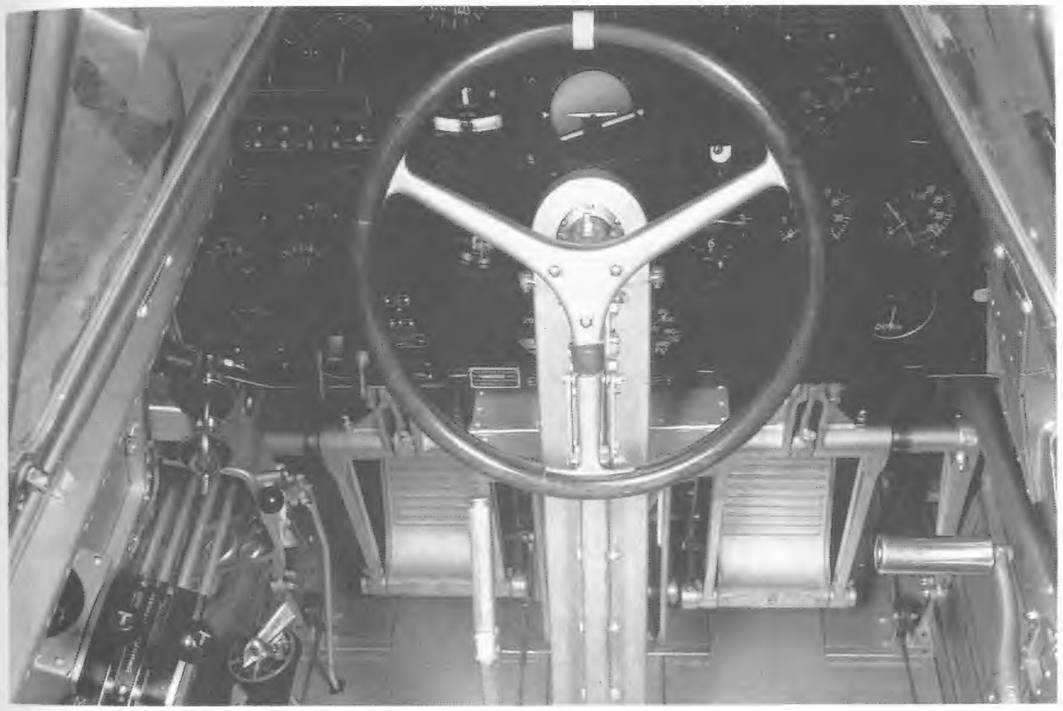
MODEL 246 (Y1B-9A) - The Model 246 was an improved version of Models 214 and 215 (Y1B-9, YB-9) ordered by the Army for service testing at the time the prototypes were purchased. As originally delivered, the Y1B-9As were outwardly identical to the YB-9 with Y1B-9 rudder tabs but had metal instead of fabric covering on their movable control surfaces, three-blade propellers, and incorporated many internal structural and equipment changes. Later, the rudders were changed to a fabric-covered type with shape and inset servo tab as used on the Model 247 transport. The engines were P & W Hornet Y1G1SR-1860B, 600 hp at 2,200 rpm at 6,000 ft and high speed increased to 186 mph with the altitude-rated engines. Military load was two ·30 cal MG and four 600 lb bombs.

The high speed of the new bomber had indicated the desirability of enclosing the cockpits for crew protection; while closed canopies called

'green-houses' were designed at the time they were not installed.

The first Y1B-9A flew on July 14, 1932, and was delivered to the Army on July 21. The last aeroplane on the contract was delivered on March 20, 1933.

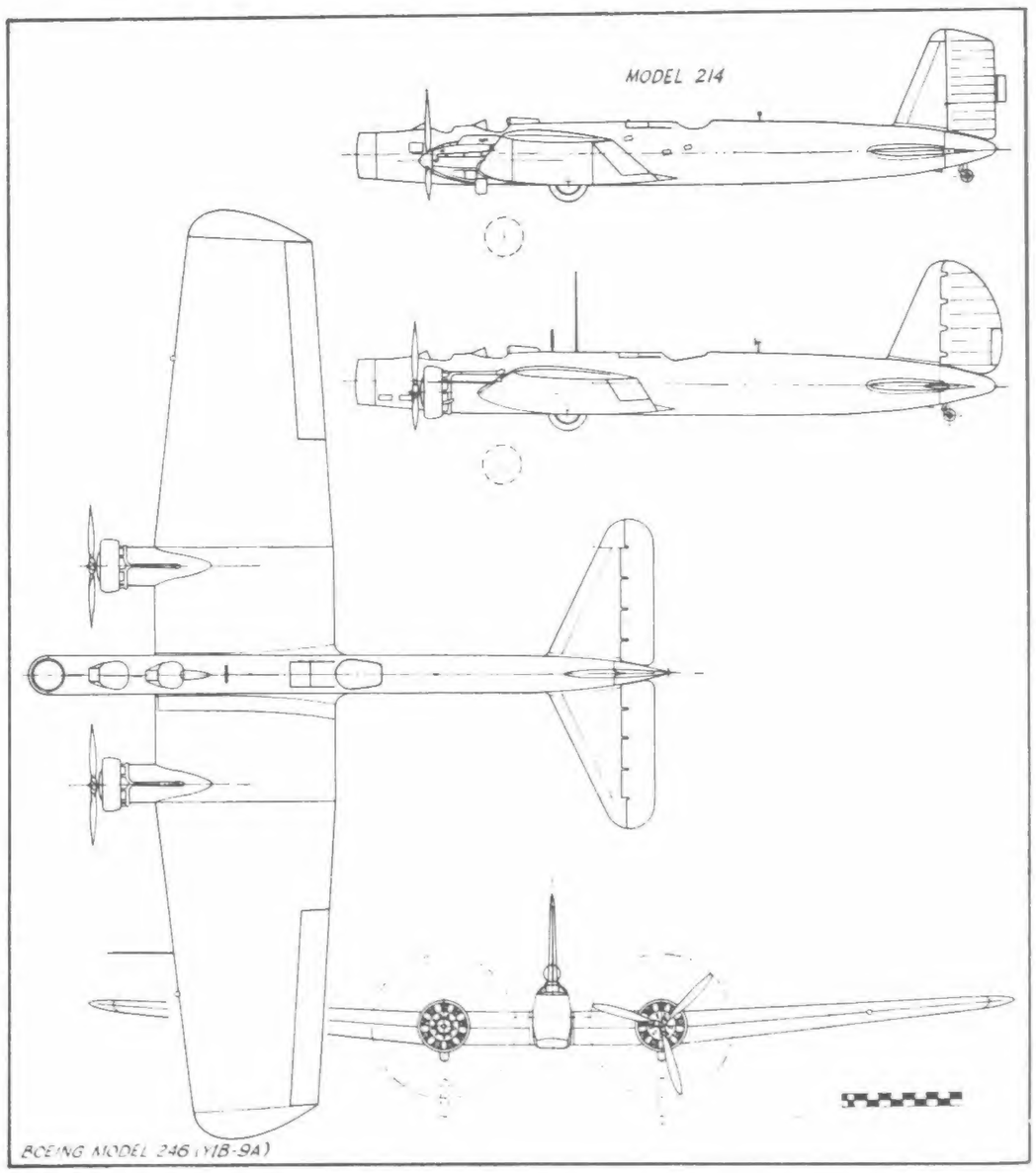
C/ns: 1671/1675
Army serial numbers: 32-303/307



The narrow pilot's cockpit of the Model 246/Y1B-9A. (*Boeing Photo 5515-B*)

Equipped to US Army bomber requirements, the Model 246/Y1B-9A was the most elaborately instrumented Boeing aeroplane up to its time - 1932. (*Boeing Photo 5442-B*)

Five service test Y1B-9As were built as Boeing Model 246. New vertical tail shapes adopted after delivery. Camouflage was for 1933 war games. (*USAF Photo G956-876F-14*)

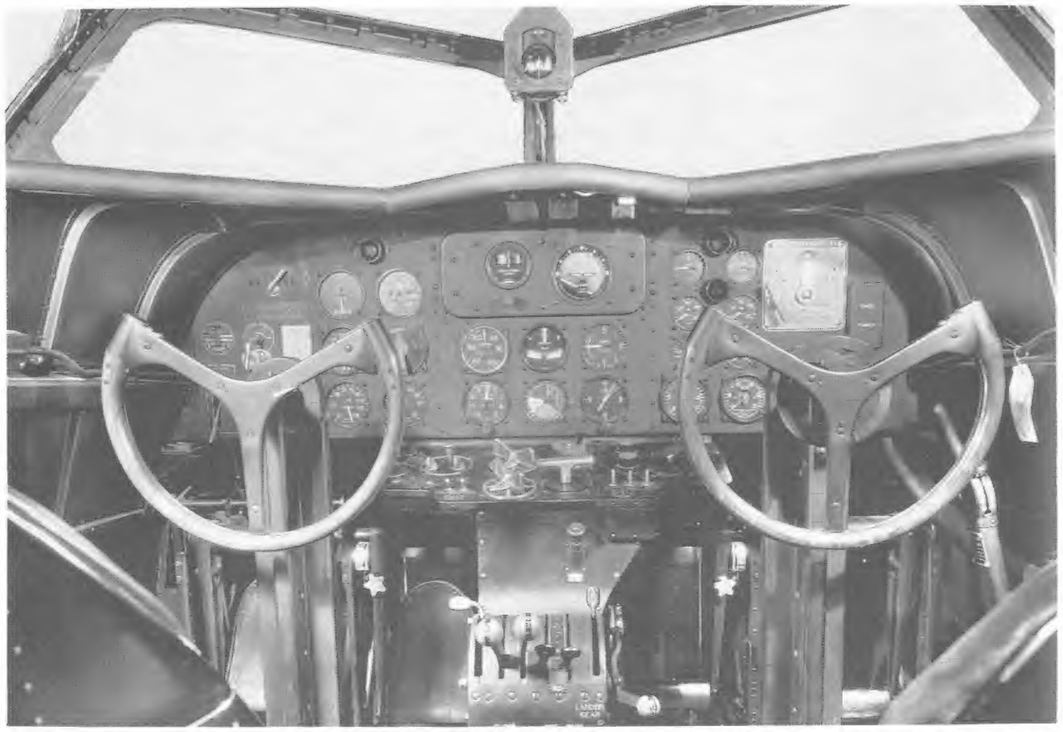


The Boeing 247 revolutionized airliner design concepts. The first, registered X-13301 and carrying Boeing Air Transport markings, is shown with original undercut windshield, small nacelles, ring cowlings, and fixed-pitch propellers. (*Boeing Photo P-6110-B*)

MODEL 247 – The 247 was a twin-engine transport incorporating the structural and aerodynamic features of the Monomail and the B-9, and like them, it revolutionized aeroplane design in its particular field. However, unlike its two predecessors, the 247 earned Boeing a return on its pioneering effort in the transport field by winning large production orders.

The 247 was slightly smaller and lighter than the Ford, Fokker and Boeing Trimotors that it was to replace, but it was 50 to 70 mph faster and could climb with one engine dead while carrying a full load. It was the first low-wing multi-engine American transport, with a configuration well suited to clean aerodynamic design but which offered a slight disadvantage from the passenger standpoint in that the main wing spars passed right through the 10-passenger cabin.

Looking forward in the cabin of the Model 247D. Note the steps for getting over the wing spars that penetrated the cabin. (*Boeing Photo 7691-B*)



Pilot's cockpit of the first Boeing Model 247. Most engine and fuel system instruments are in front of the co-pilot at the right. Flight instruments used by both pilots are centred between them. (*Boeing Photo 6245-B2*)

A total of 70 Boeing 247s was ordered by the various airlines that comprised United Air Lines in 1932, and 59 of the first 60 were completed for UAL as Model 247 under ATC 500. The remainder were completed as Model 247D, and all of the plain 247s remaining in service for United through 1935 were converted to 247Ds. The last two 247s for a total of 61 were shipped to Luft Hansa in Germany after being assigned temporary US registration numbers separate from the rest of the 247 series. The first 247 flew on February 8, 1933, and while it was a production aeroplane, it served as the test article for certification of the series. The original colour scheme of the 247s was all grey, and resulted from the anodized finish of the dural skin rather than from paint. Slightly different shades from different batches of metal gave some of the aeroplanes a patched look. This was overcome in 1940 when UAL painted its 247 fleet white with blue trim.

Specifications and performance for the Model 247 series are presented in the table on page 213.

C/ns: 1682/1710, 1712/1741, 1944, 1945
Registrations: NC-13301/13359, D-AGAR (NC-90Y), D-AKIN (NC-91Y)

• 247A – The 247A was the 30th Model 247 in production sequence but carried the lowest civil registration number of the series. It was specially modified for use as an executive transport and research aeroplane for the Pratt & Whitney Division of Aircraft United Corp. It differed considerably from the standard 247 in interior arrangement and in power plant, which

Model 247A was the thirtieth 247 built but carried a registration number one digit lower than that of the prototype. The small-diameter cowlings housing twin-row P & W Twin Wasp Jr engines, plus silver paint, distinguish the 247A from the standard models. (*Photo by Gordon S. Williams*)

was the new 14-cylinder P & W Twin Wasp Jr engine of 625 hp. The differences resulted in a new ATC, No. 524. The 247A first flew on September 14, 1933, and was delivered to United Aircraft on November 4, remaining in that company's service until scrapped after WW-II.

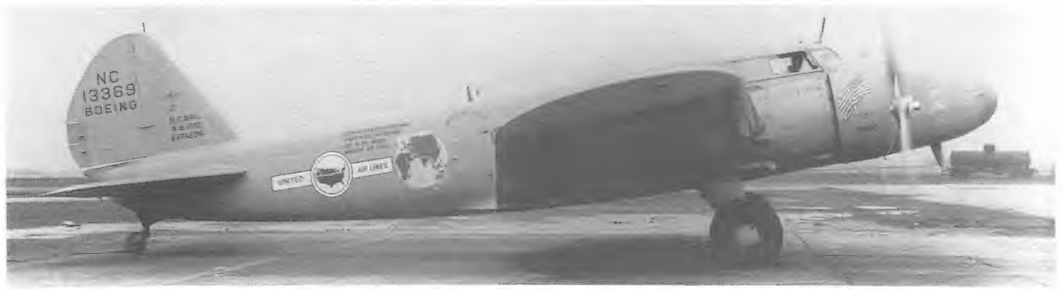
C/n: 1711
Registration: NC 13300

• 247D (C-73) – The 247D was an improved version of the original Model 247. No Model 247B or C was built. The principal external recognition features were full NACA cowlings replacing the drag rings, fabric-covered movable tail surfaces instead of metal, controllable-pitch propellers, and windshields that sloped upward and aft. These features, plus gearing of the Wasp engines, gave the D version a cruising speed in excess of the top speed of the basic 247 and resulted in a new ATC, 558. Thirteen 247Ds were built as such, and existing 247s except the 247A and the two delivered to Germany, were eventually modified to 247D standard and redesignated. However, not all of the conversions included the D-type windshield.

The first 247D was intended to be the third 247 sold to Germany. After factory test with the non-sequential registration of X-12272, it was registered NC-92Y for export. When the sale was not completed, it was sold to the Phillips Petroleum Company. The registration of NC-2666 was assigned at Phillips's request as this figure had an advertising tie-in with a numbered brand of gasoline that Phillips sold.

One 247D had a rather exceptional career. Originally ordered by UAL, it was completed for Col Roscoe Turner and Clyde Pangborn as an entry in the 1934 MacRobertson air race from London, England, to Melbourne, Australia. The cabin was used for extra fuel tanks, and the aeroplane was registered NR-257Y at Turner's request and again a commercial tie-in with a sponsor's numbered product. The racing number of the machine was 55. After being second in the transport division of the race and third in overall speed, the Turner 247D was returned to UAL and placed in airline service. It was re-registered as NC-13369 to preserve the continuity of registration numbers in UAL's fleet, which now ran from NC-13301 through NC-13369. An existing 247D built for Western Air Express as NC-13369, was renumbered NC-13370 to preserve the continuity of the UAL numbering.

Thirteen Model 247Ds were built as such, with full NACA cowlings, controllable-pitch propellers, and sloping windshields as shown. Earlier 247s were modified to 247D standard and redesignated. (*Photo by Gordon S Williams*)



The 247D that was placed third in the London–Melbourne race of 1934 and put into service by United Air Lines with a map of the route on its side and large placard that proclaimed its racing accomplishments. (*A U Schmidt Collection*)

Twenty-seven 247Ds were acquired by the Army during WW-II. Red tail, nose, and engine cowlings identify this one as an instrument trainer. (*Photo by Peter M Bowers*)

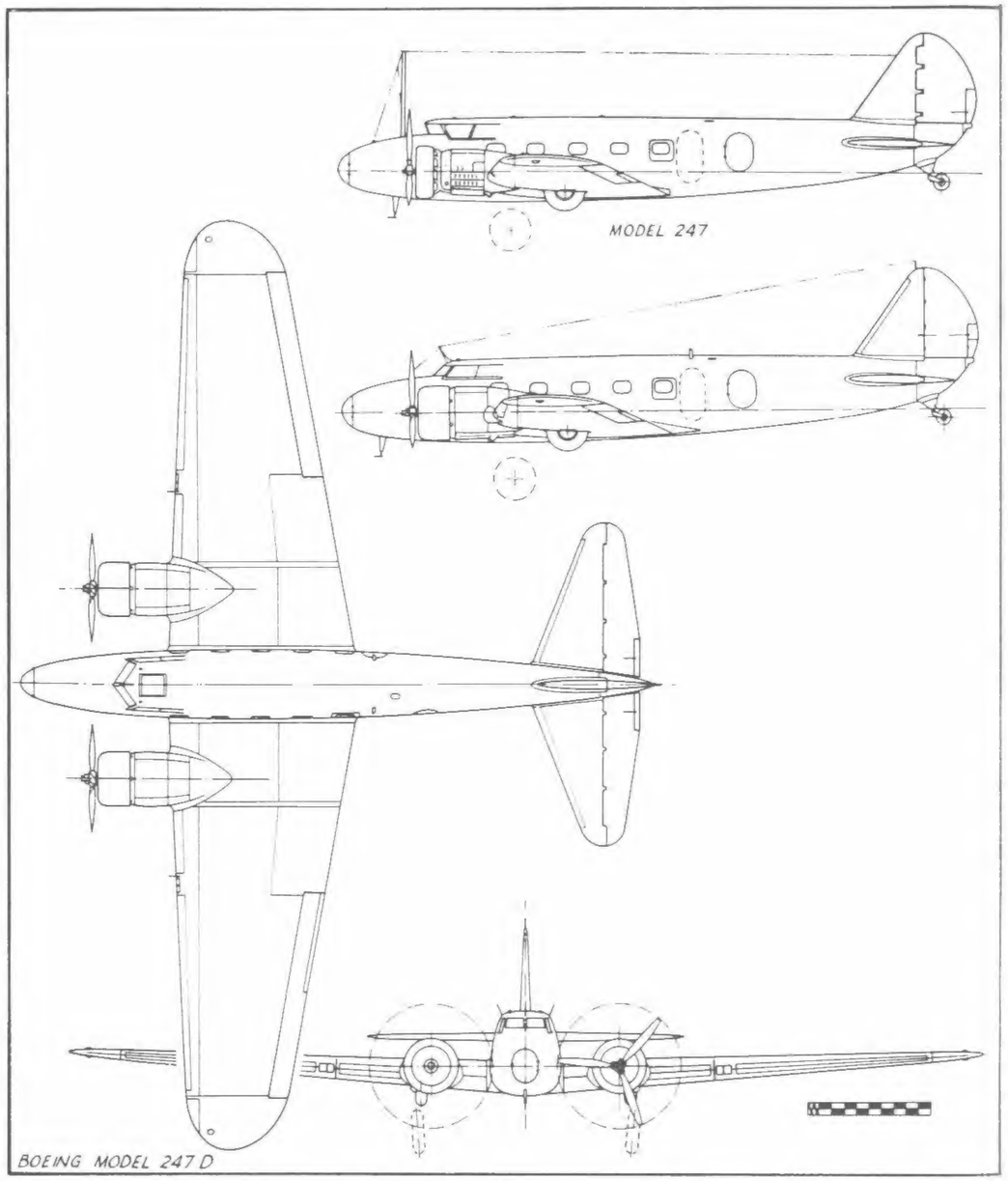
The first 247, shown in 1940 UAL markings, was redesignated 247E when used to test new features for the 247D and retained the E designation when returned to the airline. (*Photo by Peter M Bowers*)

UAL sold NC-13369 to the Union Electric Company in January 1936, and it stayed with the organization until August 1939, when it was obtained by the Civil Aeronautics authority (CAA, now FAA for Federal Aviation Agency). The original CAA registration was NS-11, later changed to N-11. The aeroplane found a final home with the National Air Museum on July 17, 1953.

C/ns	*Registrations*
1946	X-12272, NC-92Y, NC-2666
1947	NC-13361
1948	NC-13362
1949	NC-13363
1950	NC-13364
1951	NC-13360
1952	NC-13366
1953	NR-257Y, NC-13369 No. 2
1954	NC-13367
1955	Export to China
1956	NC-13368
1957	NC-13370 (Ex-13369 No. 1)
1958	NC-13365

One 247D (c/n 1726, formerly a 247) was used for research in instrument and automatic landing systems by the Royal Air Force during WW-II and carried the military serial number DZ 203. This followed a short period of service in the Royal Canadian Air Force with RCAF serial number 7655. A total of eight 247Ds were in the RCAF. See Appendix VII for RCAF serial numbers and corresponding c/ns.

The sole RAF 247D, DZ203, in full wartime camouflage, circa 1942. (*RAF Photo via Boeing*)



• C-73 – In 1942, 27 Boeing 247Ds were drafted into the US Army Air Corps and given the military designation C-73. Some underwent varying degrees of modification while in service. A number were fitted with military P & W R-1340-AN-1 engines in place of the commercial S1H1G Wasps and fitted with two-blade propellers and cowlings from North American AT-6 series aeroplanes. The C-73s were declared surplus in 1944 and were acquired by various private owners and small airlines, some regaining their original NC-13300 series registrations but most being given later numbers, especially those that were acquired by owners outside the United States and eventually sold to new American owners (see Appendices III and IV).

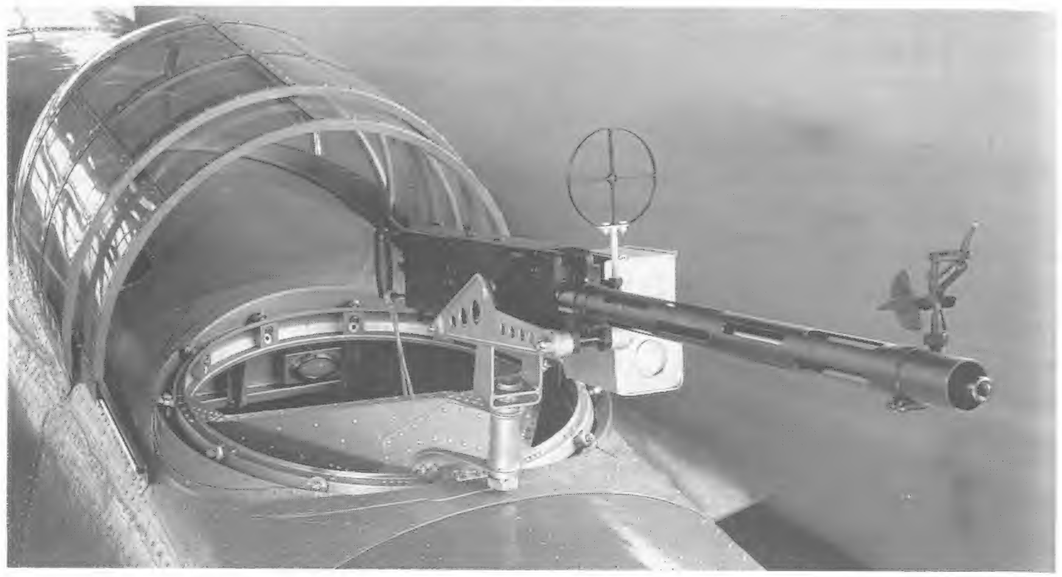
Army serial numbers: 42-38274, 38275, 56642, 57153, 57208/57211, 57508, 57509, 61094, 68336, 68363/68373, 68853, 68854, 68859, 78017 (See Appendix V for corresponding c/ns and registrations)

• 247E – This was a special designation given to the first 247, NC-13301, when it was used at the factory to flight-test new features being developed for the improved 247D model. Several different vertical tail surface shapes were tried, but the final 247D shape was the same as the original with fabric covering in place of the original metal. Although identical to the 247D, the test aeroplane retained the E designation upon return to airline service. It was eventually drafted into the Army Air Corps as a C-73 during WW-II.

• 247Y – This was the seventh 247D (c/n 1952) delivered originally to UAL as NC-13366 but returned to Boeing and converted to 247Y in January 1937. This was a private military type aeroplane with two fixed ·50 calibre machine-guns mounted in the nose and a single flexible gun at the rear of the cabin, which was reduced to six-passenger capacity. The normal range was extended by installation of four of the cabin fuel tanks from the MacRobertson race 247D. Since the aeroplane was structurally and aerodynamically a standard 247D, it was shipped directly to the customer in China without being assembled for factory flight-testing and consequently was not photographed before leaving the country.

TECHNICAL DATA – 247 SERIES

Boeing Model	*247*	*247A*	*247D*
Span:	74 ft	74 ft	74 ft
Length:	51 ft 4 in	51 ft 4 in	51 ft 7 in
Height (overall):	15 ft 5 in	16 ft 5 in	12 ft 1¾ in
Wing area:	836·13 sq ft	836·13 sq ft	836·13 sq ft
Empty weight:	8,400 lb	8,975 lb	9,144 lb
Gross weight:	12,650 lb	12,405 lb	13,650 lb
Power plant:	P & W Wasp S1D1 550 hp at 2,200 rpm at 5,000 ft	P & W Twin Wasp Jr SGR-1535, 625 hp at 2,400 rpm at sea level	P & W Wasp S1H1G 500 hp at 2,200 rpm at 8,000 ft
Max speed:	182 mph	198 mph	200 mph
Cruising speed:	155 mph	170 mph at 60% power	189 mph at 12,000 ft
Range:	485 miles (208 gal)	650 miles (290 gal)	745 miles (273 gal)
Rate of climb:	1,320 ft/min	1,170 ft/min	1,150 ft/min
Service ceiling:	18,400 ft	22,700 ft	25,400 ft
Absolute ceiling:	20,500 ft	24,100 ft	27,200 ft
Payload:	10 passengers, baggage, 400 lb mail	6 passengers or test equipment	10 passengers baggage, 400 lb mail



Dorsal gunner's cockpit and ·50 calibre machine-gun installed on Model 247Y, a Chinese Warlord's private airliner. (*Boeing Photo P-9366-B*)

MODEL 248 (XP-936, XP-26, Y1P-26, P-26) – Model 248 was an entirely new fighter design incorporating both Boeing ideas and certain features proposed by the Army Air Corps. Design work was begun at Boeing expense in September 1931, and an Army Bailment Contract was signed on December 5, 1931, specifying that the Army would provide engines and instruments for three test aeroplanes with the experimental designation of XP-936. Construction began in January 1932, and the first aeroplane was flown on March 20, then to Wright Field for Army evaluation. The second was flown to Anacostia, Maryland, for demonstration to the Navy, then statically tested by the Army at Wright Field. The third was sent to Selfridge Field, Michigan, for service testing.

Shortly after testing of the two XP-936s began, the Army bought them under a standard purchase contract signed on June 15, 1932, and assigned

Model 248, tested by the Army as XP-936, was the link between the old and the new concepts of fighter design – retaining such old features as open cockpit, external bracing, and fixed landing gear on a new all-metal low-wing monoplane. (*Boeing Photo P-9366-B*)

the designation of XP-26. This was soon changed to the service test designation of Y1P-26, and eventually to plain P-26.

The P-26 was an entirely new design for Boeing, and while structural features drew heavily on such other all-metal models as the Monomail, the 202/205 fighter, and the 218, the use of wire-braced wings and a non-retractable undercarriage seemed to be a step backward in view of recent company experience with retractable undercarriages and cantilever wings. However, the external bracing allowed a lighter structure and wires produced less total drag than rigid struts. The fixed undercarriage added drag but reduced weight and structural complexity and provided a structurally efficient low anchor point for flying wires.

The rear portion of each undercarriage unit consisted of an inverted tubular bipod fastened to the front and rear wing spars. The flying wires were attached to the apex, and the wheel pivoted about the apex on an arm, with the landing loads being absorbed through a shock absorber strut connecting the wheel axle to the front spar. The entire lower portion of the undercarriage was enclosed by streamline wheel fairings, or pants.

It is interesting to compare the general performance of the XP-936 with that of the P-12F, the last production Boeing biplane fighter for the Army, which was in production at the time the XP-936 was delivered. Powered with a slightly later version of the same engine that gave it only a 20 hp advantage, the XP-936 was only 39 lb heavier than the P-12F but 27 mph faster and outclimbed it by 476 ft/min. The P-26 fell 800 ft short of the biplane's absolute ceiling.

TECHNICAL DATA – XP-936

Type:	Fighter
Accommodation:	1 pilot
Power plant:	P & W SR-1340E Wasp 522 hp at 2,200 rpm at 10,000 ft
Span:	27 ft
Length:	23 ft 5·13 in
Height:	7 ft 9 in
Wing area:	150 sq ft
Empty weight:	2,070·5 lb
Gross weight:	2,740 lb
Max speed:	222 mph
Cruising speed:	190 mph
Climb:	2,260 ft/min
Service ceiling:	30,700 ft
Range:	758 miles on 50 gal
Armament:	One ·30, one ·50 cal MG or two ·30 cal, five 30 lb bombs or two 122 lb bombs
C/ns:	1678/1680
Army serial numbers:	32-412/414

Boeing Model 264 was designed as an improvement over the Model 248 (XP-936) and featured full cantilever wing, retractable landing gear, and enclosed cockpit. XP-940 configuration shown. (*Boeing Photo*)

MODEL 264 (XP-940, YP-29 Series) – Model 264 was a new and more advanced fighter design developed between the appearance of the XP-936/P-26 (Model 248) and the delivery of the P-26A (Model 266). As in the case of the XP-936, the new model was initiated as a private venture by Boeing in close collaboration with the Army, was originally tested on a Bailment Contract under which the experimental military designation of XP-940 was assigned, and ended with three aeroplanes being bought by the Army as YP-29, YP-29A, and YP-29B.

In general design, the P-29 differed from the P-26 mainly in having full-cantilever wings, which carried a retractable undercarriage similar to that originated on the Monomail (Model 200). Fuselage and tail construction was the same as the P-26 and the engines were the same as those on the production P-26A. The cleaner design resulted in an aeroplane

The YP-29 was the second Model 264 to fly and differed from the first in having a greatly enlarged cockpit canopy for pilot comfort and visibility (*Boeing Photo 7521*)

16 mph faster than the P-26A but the greater weight cut down the ceiling and manoeuvrability and cancelled an intended P-29A production order.

• XP-940 – The first of the three aeroplanes completed (actually the second in c/n sequence) was test flown on January 20, 1934, and was flown to Wright Field for Army testing on January 25. If featured a narrow cockpit enclosure that was essentially a transparent continuation of the pilot's oversize headrest to the windshield frame. This duplicated the installation of the Navy XF7B-1 (Model 273) which carried a later Boeing designation but had flown earlier. The XP-940 was returned to the factory in March for modification and became the YP-29A.

• YP-29 – Because of military dissatisfaction with the narrow cockpit enclosures of the XF7B-1 and the XP-940, the second Model 264, designated YP-29 because of a purchase contract having been signed following testing of the XP-940, was completed with a large and roomy glasshouse enclosure around the cockpit. This satisfied the requirement for pilot protection at 250 mph operating speeds. Because of the increased landing speed of the new monoplane design, the YP-29 was returned to the factory for the installation of wing flaps. Following service testing by the Army and Boeing, which included trials with controllable-pitch propellers, the service test designation was dropped and as plain P-29 the aeroplane was sent to the NACA facilities at Langley Field, Virginia, for research purposes.

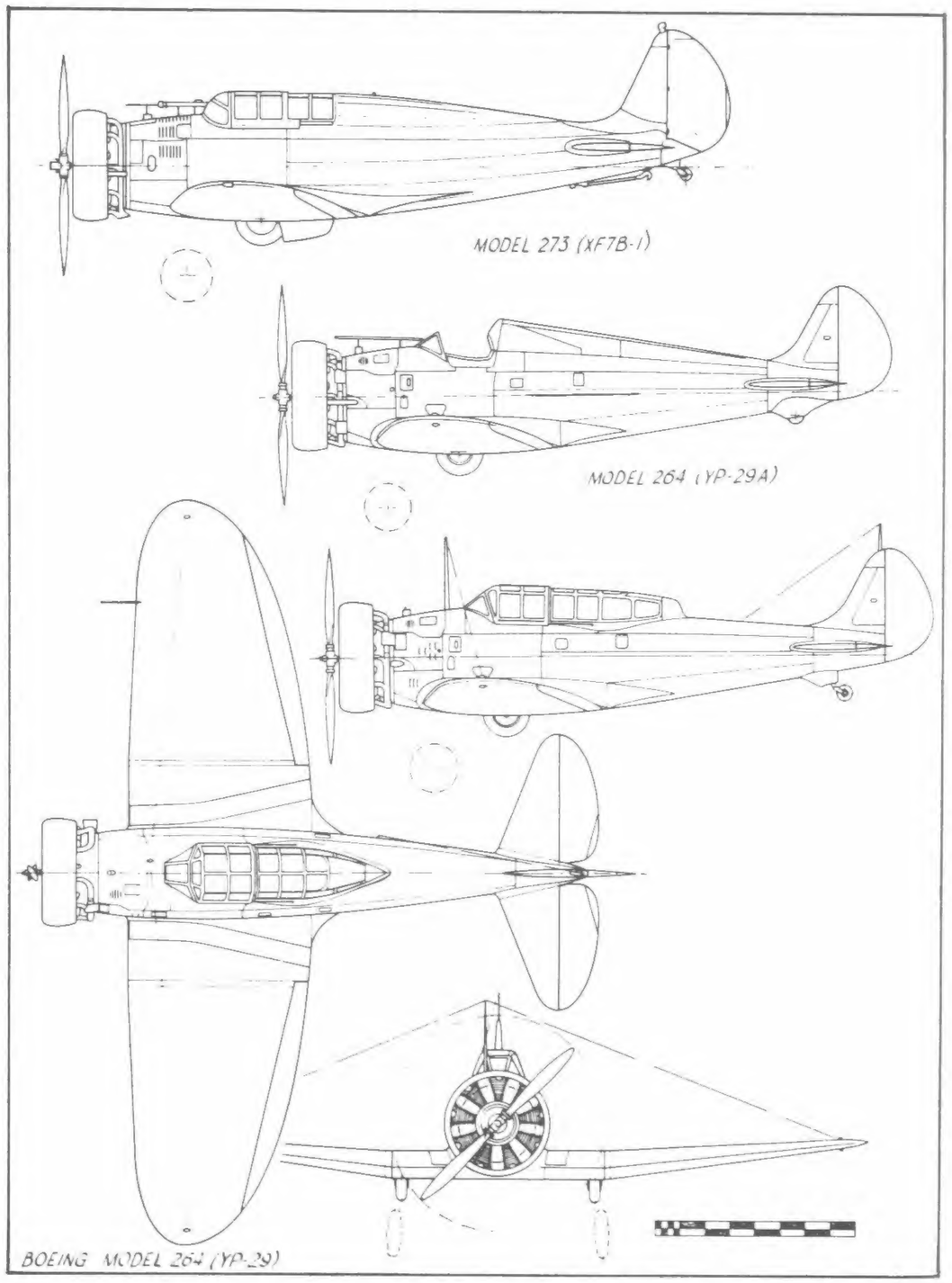
TECHNICAL DATA – YP-29

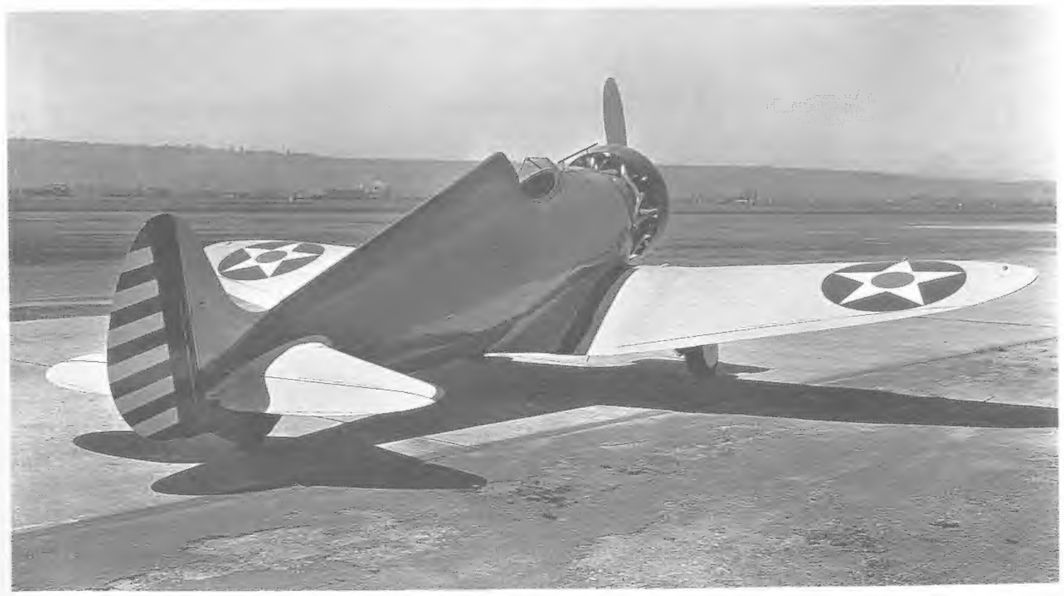
Type:	Fighter
Accommodation:	1 pilot
Power plant:	P & W R-1340-35 Wasp 600 hp at 2,200 rpm at 10,000 ft
Span:	29 ft 4·44 in
Length:	24 ft 11·75 in
Wing area:	176·6 sq ft
Empty weight:	2,509 lb
Gross weight:	3,518 lb
Max speed:	250 mph
Cruising speed:	212 mph 60% power
Climb:	1,600 ft/min at 10,000 ft
Service ceiling:	26,000 ft
Range:	800 miles on 113 gal
Armament:	One ·30 cal, one ·50 cal MG, ten 17 lb bombs
C/n:	1941
Army serial number:	34-23

• YP-29A – After testing the XP-940, the Army decided to buy it and its two sister ships. Upon its return to the Army following modification in April 1934, it was known as YP-29A and eventually became P-29A.

The narrow cockpit enclosure of the XP-940 was replaced by a standard open cockpit installation, but the distinctive long headrest that extended to the tail was retained. The full NACA cowling for the engine was replaced by a drag ring similar to that on the YP-29. Specifications and performance were the same as those for the YP-29.

C/n: 1942
Army serial number: 34-24





The original cockpit enclosure of the XP-940 was replaced by an open cockpit and a redesigned headrest and the aeroplane became YP-29A when purchased by the Army. (*Boeing Photo 7350-B*)

• YP-29B – The third Model 264 was completed as YP-29B with an open cockpit configuration similar to that of the YP-29A. The only outward differences were the one piece wing flap similar to that of the YP-29, an additional one degree of dihedral in the wing, and an oleo tail wheel assembly similar to that of the YP-29. The YP-29B was sent to Chanute Field, Rantoul, Illinois, for service testing.

C/n: 1943
Army serial number: 34-25

The third Model 264, designated YP-29B, combined the open cockpit of the YP-29A with the one-piece wing flap of the YP-29 and incorporated slightly increased dihedral. (*Boeing Photo 7631-B*)

MODEL 266 (P-26A, P-26C) – After testing the XP-936s, the Army ordered 111 production versions under the designation of P-26A. This was later increased to a total of 136 aeroplanes, the additional aircraft being completed as P-26B and C.

The P-26A (Boeing Model 266), popularly named 'Peashooter', was the production version of the XP-936 prototypes. (*USAF Photo*)

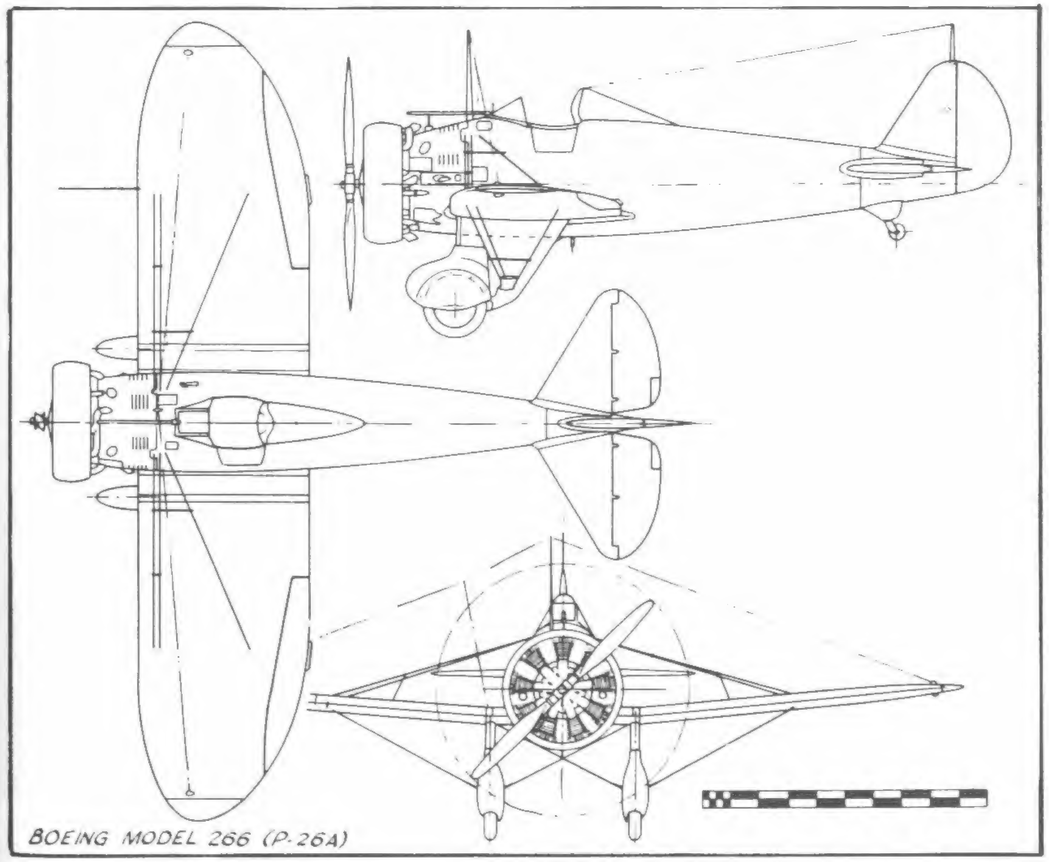
• P-26A – Outwardly, the P-26A differed from the prototypes only in that the wheel pants did not project aft of the undercarriage strut fairing. Originally, the P-26As had the low streamline headrests of the prototypes, but these were soon increased in height by 8 in for pilot protection after one of the early models went over on its back following a landing on soft ground and killed the pilot without seriously damaging the aeroplane. Inwardly, the P-26A wing structure was considerably revised and such service equipment items as flotation gear and radio were added. The first P-26A made its maiden flight on January 10, 1934, and the last aircraft of the initial order for 111 was delivered on June 30, 1934. The unit price for a P-26A in such

The Air Museum of Ontario, California, obtained a P-26A from Guatemala in 1957. In 1962, the Autonetics Division of North American Aviation restored it to flying condition with the colourful 1935 markings of the 34th Pursuit Squadron. (*Autonetics Photo*)

The emergency flotation kit for the P-26A was carried externally above the wing root. The air bags had to be specially contoured in the shape of a dumb-bell in order to inflate past the upper wing bracing wires. (*Wright Field Photo 48944*)

quantities less engine and GFE, was $9,999 compared to $10,197 for the P-12E biplane in the same quantity.

After the P-26As were in service, the Army became dissatisfied with the relatively high landing speed. Wing flaps, developed and tested by the Army on a P-26A and by Boeing on the Model 281, the export version of P-26A, were installed on all P-26As then in service and on the P-26Bs and Cs still in the factory.



P-26C was also Boeing Model 266, and differed only in fuel and carburetion systems. Original tail-wheel style shown was later modified as shown in P-26A photos. (*Photo by Gordon S Williams*)

All P-26 models had been withdrawn from regular squadron use when WW-II began. Most of those stationed overseas were sold to the governments of the Philippines and Panama, and two were sold to Guatemala. One of the Philippine P-26s is credited with shooting down the

The crowded cockpit of a Boeing P-26C, with radio, one ·30 calibre machine gun (left) and one ·50 calibre (right) on the floor. (*Boeing Photo 8388-B*)

first Japanese aeroplane during the early attacks on the islands. Several of the Panama P-26s were later acquired by Guatemala and were still active in 1955. One was obtained from Guatemala by the Planes of Fame Museum, now of Chino, California, where it has been restored to flying condition in its original US Army markings, and a second was obtained from the same source by the National Air and Space Museum of the Smithsonian Institution and is currently on display in Washington, D.C.

C/ns: 1804/1914
Army serial numbers: 33-28/138

• P-26C – Twenty-three of the 25 aeroplanes added to the original order for 111 P-26As were built as P-26C with such slight differences in the fuel and carburetion systems that the factory model number was not changed. The first P-26C was delivered on February 10, 1936, and the last on March 7. After about a year in service, all of the P-26Cs were converted to P-26B standard (Boeing 266A) by the installation of fuel injection engines and revision of the fuel system and its controls.

C/ns: 1915, 1917, 1918, 1920/1939
Army serial numbers: 33-181, 183/203

• 266A (P-26B) – Two of the 25 aeroplanes added to the initial P-26A order were completed as P-26B, differing from the P-26As in being fitted with fuel injection engines. The attendant revisions to the fuel system, plus the fact that the P-26Bs were the first P-26s built with wing flaps as initial equipment, justified a change in the factory model designation. The first P-26B was delivered to the Army on June 20, 1934, the second on June 21.

After the fuel injection system had been satisfactorily service tested, the Army decided that the feature should be incorporated in the P-26Cs. However, the factory model designation of the P-26C was not changed and it remained Model 266.

Because of structural differences, which included original installation of wing flaps, P-26B was Boeing Model 266A. Flaps were later added to all P-26As and Cs. (*Boeing Photo P-8147-B*)

The cost of a P-26B was $14,009, less engine and GFE.

C/ns: 1916, 1919
Army serial numbers: 33-179, 180

TECHNICAL DATA - P-26 SERIES

Boeing model	*266*	*266A*	*266*
Military model	*P-26A*	*P26-B*	*P-26C*
Span:	27 ft 11·6 in	27 ft 11·6 in	27 ft 11·6 in
Length:	23 ft 7·25 in	23 ft 9 in	23ft 9in
Height:	10 ft 0·38 in	10 ft 0·38 in	10 ft 0·38
Wing area:	149·5 sq ft	149·5 sq ft	149·5 sq ft
Empty weight:	2,196·5 lb	2,301·6 lb	2,332·6 lb
Gross weight:	2,955·1 lb	3,060·2 lb	3,074·7 lb
Accommodation:	1 pilot	1 pilot	1 pilot
Power plant:	P & W R-1340-27 600 hp at 2,200 rpm at 6,000 ft	P & W SR-1340-33 600 hp at 2,200 rpm at 6,000 ft	-27 to -33
Max speed:	234 mph	235 mph	235 mph
Cruising speed:	200 mph at 60% power, all models		
Range:	635 miles	635 miles	635 miles
Rate of climb:	2,360 rpm	2,360 rpm	2,360 rpm
Service ceiling:	27,400 ft	27,000 ft	27,000 ft
Absolute ceiling:	28,300 ft	28,000 ft	28,000ft
Armament:	One ·30, one ·50 cal MG or two ·50 cal MG Two 100 lb bombs or five 30 lb bombs		

MODEL 273 (XF7B-1) - While carrying a later Boeing model number, the Model 273 developed for the Navy as the XF7B-1 was a slightly earlier design than the Model 264 developed for the Army as the XP-940/YP-29 series. Both models were essentially the same except for some necessary service differences.

The XF7B-1 was designed to a Navy specification issued on December 6, 1932, and a contract for its construction was signed on March 20, 1933. Model 273 was selected for construction and test from four monoplane proposals submitted and incorporated several notable 'firsts', both for Boeing and the Navy. It was the first Boeing to be fitted with a controllable-pitch propeller before initial testing and the first to have flaps fitted, and was the first low-wing cantilever monoplane ever submitted to the Navy as a carrier fighter. The first flight was made on September 14, 1933.

After preliminary demonstration flights for Navy officers in Seattle, the XF7B-1 was flown to Hartford, Conn, for engine and cowling modifications by Pratt & Whitney. It was delivered to the Navy test centre at Anacostia, Maryland, on November 11, 1933. As the result of Navy criticism of high

The XF7B-1 had a later Boeing Model number, 273, than the YP-29s, but flew much earlier. This 1933 photo shows the original XP-940-type closed cockpit. (*Boeing Photo 6701-B*)

landing speed and the lack of downward visibility, the XF7B-1 was returned to the factory for conversion to a standard open cockpit design and the addition of a split flap along the trailing edge of the centre section. While other characteristics of the aeroplane compared favourably with new Army monoplane fighters then under test, the Navy still felt that its needs were best met by the biplanes. Compared to them, the average 357·2 ft take-off run of the Boeing monoplane was excessive for carrier operation, the landing speed of 70 mph was too high, the manoeuvrability was inferior, and the low position of the thick wing obsured the horizontal tail surfaces from the vision of the Landing Signal Officer on the carrier deck and made it difficult for him to judge the approach speed. These monoplane characteristics did not become acceptable to the Navy until 1938, when the first production orders for monoplane shipboard fighters were placed, and the XF7B-1 became an example of a gamble that lost because the product was too far ahead of its market.

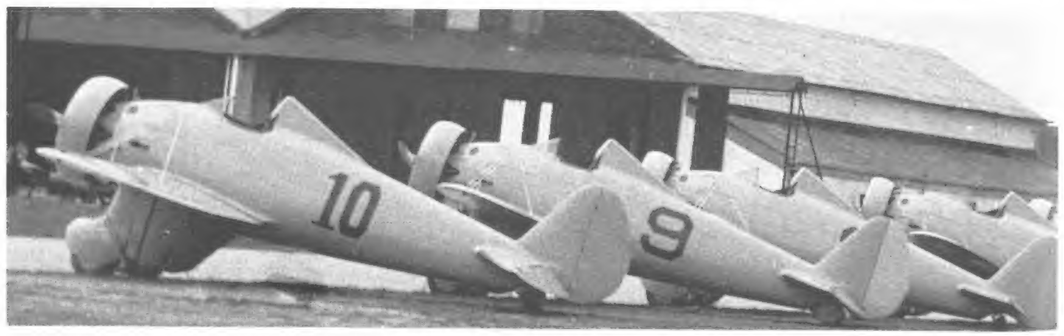
XF7B-1 photographed in 1935 with later open cockpit configuration and revised engine cowling. (*Boeing Photo P-7838-B*)

The XF7B-1 was scrapped after extensive in-flight damage was incurred during a 415 mph dive in March 1935. The centre panel of the windshield collapsed during the dive, and this apparently caused the pilot to make too abrupt a pull-out, for the measured 'g' load was 12·1 while the design load factor was only 9·0. The structure was seriously sprung, but the Navy pilot was able to fly the aeroplane home and land it safely. The cost of repair could not be justified in view of the fact that the Navy had already decided against production of the F7B-1 design. Total cost of the X7FB-1 to the Navy was $70,014.

TECHNICAL DATA - XF7B-1

Type:	Fighter
Accommodation:	1 pilot
Power plant:	P & W SR-1340-30 550 hp at 2,200 rpm at 10,000 ft
Span:	31 ft 11 in
Length:	27 ft 7 in
Height:	7 ft 5 in
Wing area:	213 sq ft
Empty weight:	2,782 lb
Gross weight:	3,651 lb
Max speed:	233 mph
Cruising speed:	200 mph at 60% power
Service ceiling:	29,200 ft
Range:	750 miles
Armament:	Two ·30 ca MG
C/n:	1803
Navy serial number:	9378

MODEL 281 - The Model 281 was an export version of the P-26A (Model 266) differing only in the details of military equipment. First flight of the Model 281 was on August 2, 1934, and early tests indicated that the landing speed was excessive for the small and unimproved fields from which an export fighter would be expected to operate. Split-type wing flaps were developed and installed, and were tested by the Army for comparison with experimental flaps that the Army had installed on a standard P-26A. As a



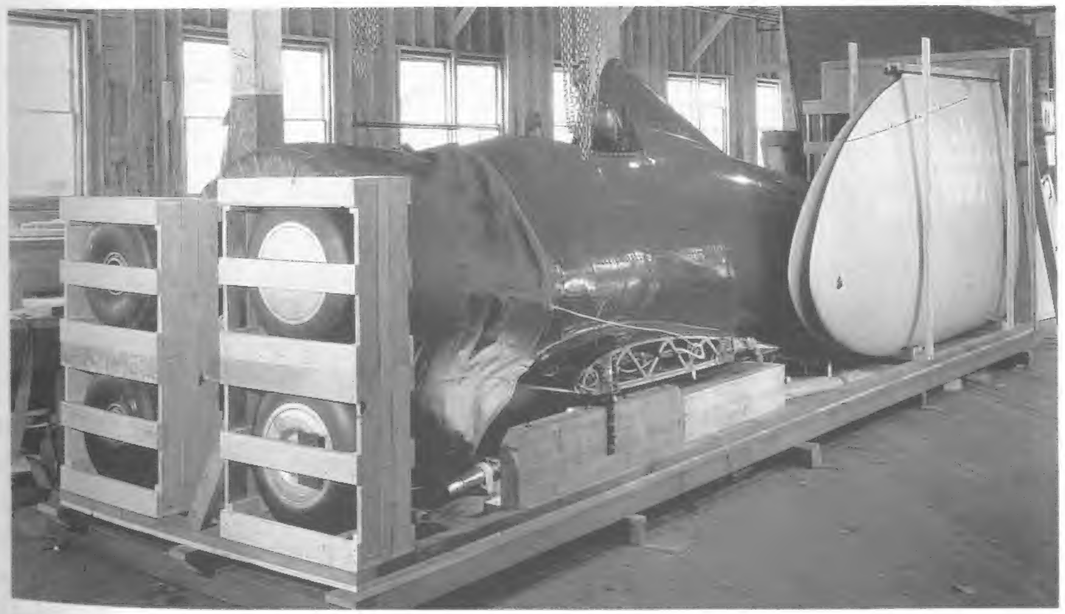
Four of 11 Models 281s, export versions of the P-26A in Canton, China. (*Photo by Herbert D Ponceti*)

One of the Model 281s exported to China. (*Photo by Herbert D Ponceti*)

result of these tests, all P-26As were returned to the factory for installation of the new flaps and all P-26 and 281 models then under construction were modified prior to completion.

One 281 was sold to Spain and the last of 11 for China was shipped on January 16, 1936. The Chinese models were purchased partly with funds raised by Chinese residents of the United States. Some American readers may remember contribution boxes on the counters of Chinese restaurants of the period. At least one of the Chinese models was supplied with an alternate undercarriage using large airwheels to permit operation from muddy fields.

C/ns:	1959/1962, 1965/1972
Civil registrations:	X-12271 and 12275 for c/ns 1959 and 1962, respectively



Model 281 disassembled and crated for overseas shipment. (*Boeing Photo 7579-B*)

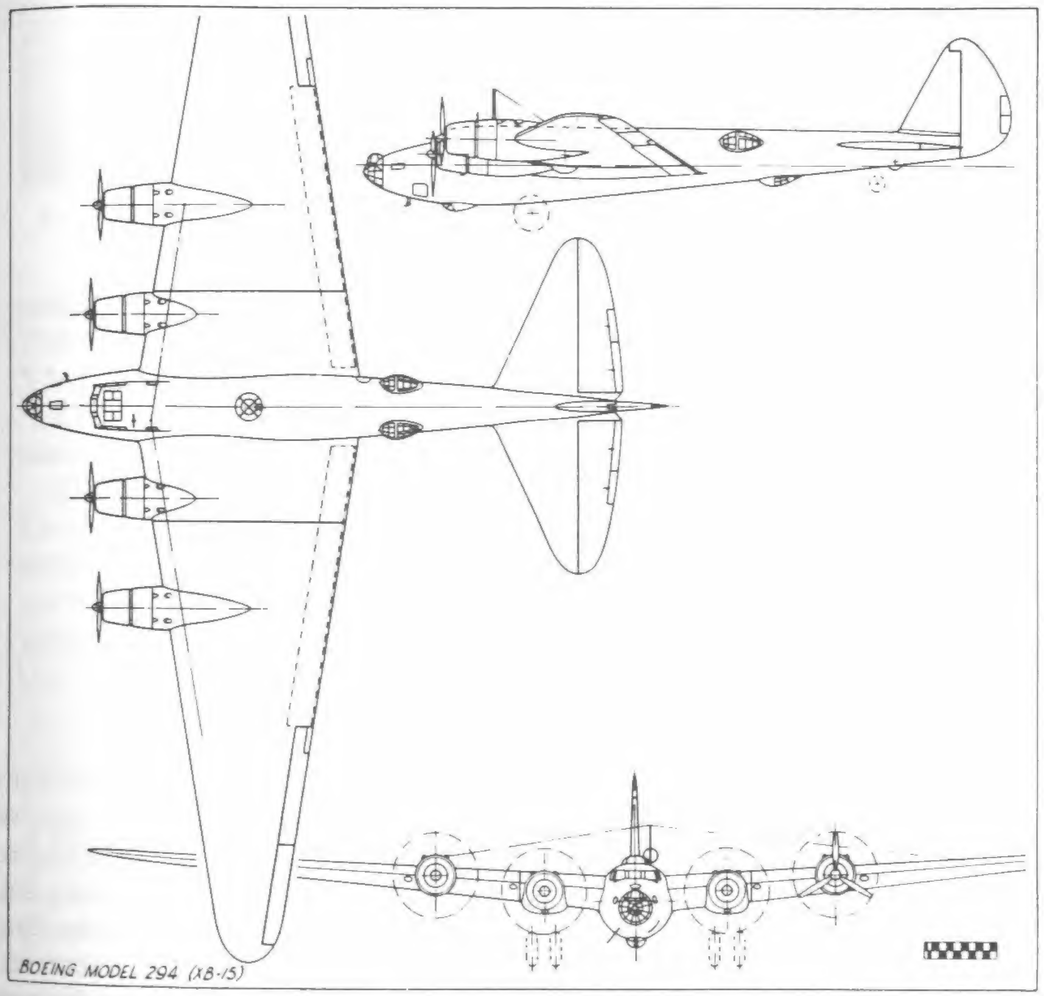
Although an older design than Model 299, which became the famous B-17, and carrying an earlier military designation, the XB-15 (Model 294) made its first flight two years later. (*Photo by Gordon S Williams*)

MODEL 294 (XBLR-1, XB-15, XC-105) – Model 294 was designed to meet an Army Air Corps request for a 'Long Range Airplane Suitable for Military Purposes' issued on April 14, 1934. The designation assigned at the time the contract was drawn was XBLR-1, for Experimental Bomber, Long Range, but this was changed to the regular bomber designation of XB-15 in July 1936.

The XB-15 was the largest and heaviest aeroplane ever built in the United States at the time of its first flight on October 15, 1937, and many new features appeared for the first time. Electrical power was supplied by two 110-volt AC generators driven by two auxiliary petrol engines, sleeping and cooking facilities were provided for the crew, and many of the mechanical

Four-man control cabin of the XB-15. Pilot and co-pilot had duplicate flight instruments with power plant and fuel instruments between them. The double door leads to the nose compartment. (*Boeing Photo 10071*)

duties of the pilot and co-pilot were taken over by a flight engineer, who had a separate station in the cockpit. Structure was generally similar to earlier Boeing monoplanes from the Monomail on except that the wing from the main spar aft was fabric covered. The wing was so thick at the root that it was possible for a member of the crew to service the engine accessory sections in flight from a passageway behind the nacelles. Because of the high gross weight, two wheels were used on each main undercarriage truck as had been done during WW-I.



The XB-15 was designed to use Allison V-3420 liquid-cooled engines, but the power plants were changed to 1,000 hp P & W R-1830 twin-row radials after wooden dummy Allisons had been installed in the mockup. The aeroplane proved to be underpowered even with these, and provided an excellent example of a typical situation, where a promising new design was handicapped by lack of the bigger power plants necessary to develop its full potential. The power of the R-1830s was sufficient, however, to permit the aeroplane to set several world records for weight carrying, including a 71,167 lb payload to 8,200 ft on July 30, 1939, and a payload of 4,409 lb 3,107 miles at 166 mph.

Two service test models, ordered as Y1B-20 with slightly larger P & W R-2180 engines, were cancelled and the single XB-15 was used as a research and development aeroplane and not as the prototype of a line of production bombers. Because of its experimental nature and low performance when compared to later models, the XB-15 was not used as a bomber during WW-II but was converted to a cargo carrier under the designation XC-105 to capitalize on its great load-carrying capacity. It was finally scrapped at Kelly Field, Texas, shortly before the end of the war.

TECHNICAL DATA - XB-15

Type:	Heavy bomber
Accommodation:	10 crew
Power plant:	P & W R-1830-11 Twin Wasp 850 hp a 2,450 rpm at 5,000 ft (1,000 hp for take-off)
Span:	149 ft
Length:	87 ft 7 in
Height:	18 ft 1 in
Wing area:	2,780 sq ft
Empty weight:	37,709 lb
Gross weight:	70,706 lb
Max speed:	200 mph at 5,000 ft
Cruising speed:	152 mph at 60% power at 6,000 ft
Service ceiling:	18,900 ft
Range:	5,130 miles
Armament:	Two ·50 cal MG, four ·30 cal MG, four 2,000 lb bombs
C/n:	1964
Army serial number:	35-277

MODEL 307 (STRATOLINER, C-75) - The Model 307 was a transport version of the Model 299H/B-17C (Chapter 8) that just escaped the label of 'converted bomber' by using an entirely new fuselage of greatly enlarged and completely circular cross-section. The wings, nacelles, power plant, and original tail surfaces were standard B-17 components except that leading edge slots were built into the wing tips. The extra fuselage width increased the 103 ft 9 in span of the B-17 wing to 107 ft 3 in. The outstanding feature of the 307 was the pressurized cabin for increased passenger comfort at altitudes that would permit the transport to fly above most of the rough weather that earlier transports had been forced to fly through. Because of its high-altitude operation, the Model 307 was given the copyrighted trade name of Stratoliner. This was only the third time that a Boeing aeroplane had been given a popular name as well as a number (the first was the 200/221 Monomail, the second was the 299/B-17 Flying Fortress).

Factory designation of the 307 series differed from previous Boeing practice in that prefixes to the basic designation were used as well as the regular suffixes that ordinarily showed development. The four aeroplanes

The prototype Model 307 Stratoliner, which was essentially a B-17C fitted with a roomy and comfortably pressurized passenger-type fuselage. (*Boeing Photo*)

ordered by Pan American Airways (PAA) were known as S-307, the five for Transcontinental and Western Air (TWA, now Trans World Airlines) were SA-307B, and the single aircraft for Howard Hughes was the SB-307B.

The specification for the 307 was drawn up in December 1935, but construction did not begin until airline orders were received in 1937.

The first 307, a PAA-307 intended for Pan American Airways, flew on December 31, 1938. The loss of the prototype during test by a foreign airline pilot did not delay production of the other nine 307s. After further testing of other models, it was found desirable to eliminate the B-17C vertical tail surfaces and install an entirely new rudder and a large dorsal fin that was to become a Boeing trademark on subsequent models. While there were detail differences, the following specifications and performance figures apply to all 307 Stratoliner models. The advertised price of a Stratoliner in 1938 was $315,000.

TECHNICAL DATA - STRATOLINER

Type:	High-altitude long-range transport
Accommodation:	33 passengers, 5 crew
Power plant:	Wright GR-1820 Cyclone, 900 hp at 2,300 rpm at 17,300 ft
Span:	107 ft 3 in
Length:	74 ft 4 in
Height:	20 ft 9 in
Wing area:	1,486 sq ft
Empty weight:	30,310 lb
Gross weight:	42,000 lb
Max speed:	246 mph at 17,300 ft
Cruising speed:	220 mph at 15,700 ft
Climb:	1,200 ft/min
Service ceiling:	26,200 ft
Range:	2,390 miles

Production version of the S-307 or PAA-307 for Pan American Airways. Compare the size and shape of the vertical tail with that of the prototype. (*Boeing Photo HS-434 or SJ-35*)

• PAA-307 – Four Stratoliners were built for Pan American Airways, and were referred to both as PAA-307 and S-307 (ATC 719). After loss of the prototype, the remaining three were delivered to the airline with the new dorsal fin and enlarged vertical tail surfaces. Externally, the PAA-307 could be distinguished from the other models by their long-chord engine cowlings and the absence of external wing flap hinges. Named *Flying Cloud, Comet* and *Rainbow*, the three remaining PAA-307s were based at Miami, Florida, for use on PAA's Latin American routes.

During WW-II they served the military, but with civil registration, and

Control cabin of Model S-307. Pilots had duplicate sets of flight instruments and made use of an extensive overhead panel. (*Boeing Photo 12300-B*)

Looking forward in the cabin of a Boeing S-307, showing single-row seating on the left, and the curtained compartments with three-abreast seats facing fore and aft. (*Pan American Airways Photo*)

were sold after the war when Model 377 Stratocruisers became available. After serving various foreign owners, in Honduras, Ecuador and elsewhere, the three PAA-307s eventually returned to US registration. The sole survivor of the original ten Stratoliners, again registered N19903, was on display at the Pima County Air Museum in Tucson, Arizona, in 1987.

C/ns:	1994, 1995, 2003, 2002
Registrations:	NC-19901/19903, 19910

• SA-307B – The five 307s built for TWA from an order of six were designated SA-307B and differed sufficiently from the four PAA-307s in detail to warrant a new ATC, 726. Externally, the most noticeable feature was the triangular external wing flap hinges and the narrow chord of the engine cowlings, similar to those of the B-17. Considerable confusion exists as to the registration numbers of the SA-307Bs because of the wide circulation of

The second of five SA-307B Stratoliners for TWA. The external hinges for the wing flaps were the original distinguishing features from the PAA-307s. Bright metal under wing clearly shows where last figure of original NX19906 registration was removed. (*Boeing Photo*)

All five TWA Stratoliners were taken over by the Army during WW-II and designated C-75. TWA crews operated them for the Army Air Transport Command under contract. (*Aeroplane Photo 11711-13s*)

photographs by Boeing and the airline showing the second TWA aeroplane (Fleet Number 401) with the registration NX 1940. The original registration of this aeroplane (Boeing c/n 1998) was NX 19906. The figure 6 was deleted and the second 9 changed to a 4 after the aeroplane had flown briefly. This altered number was used to publicize the '1940 Airliner' when it was flown on a pre-service tour of TWA's routes and was retained for subsequent TWA service.

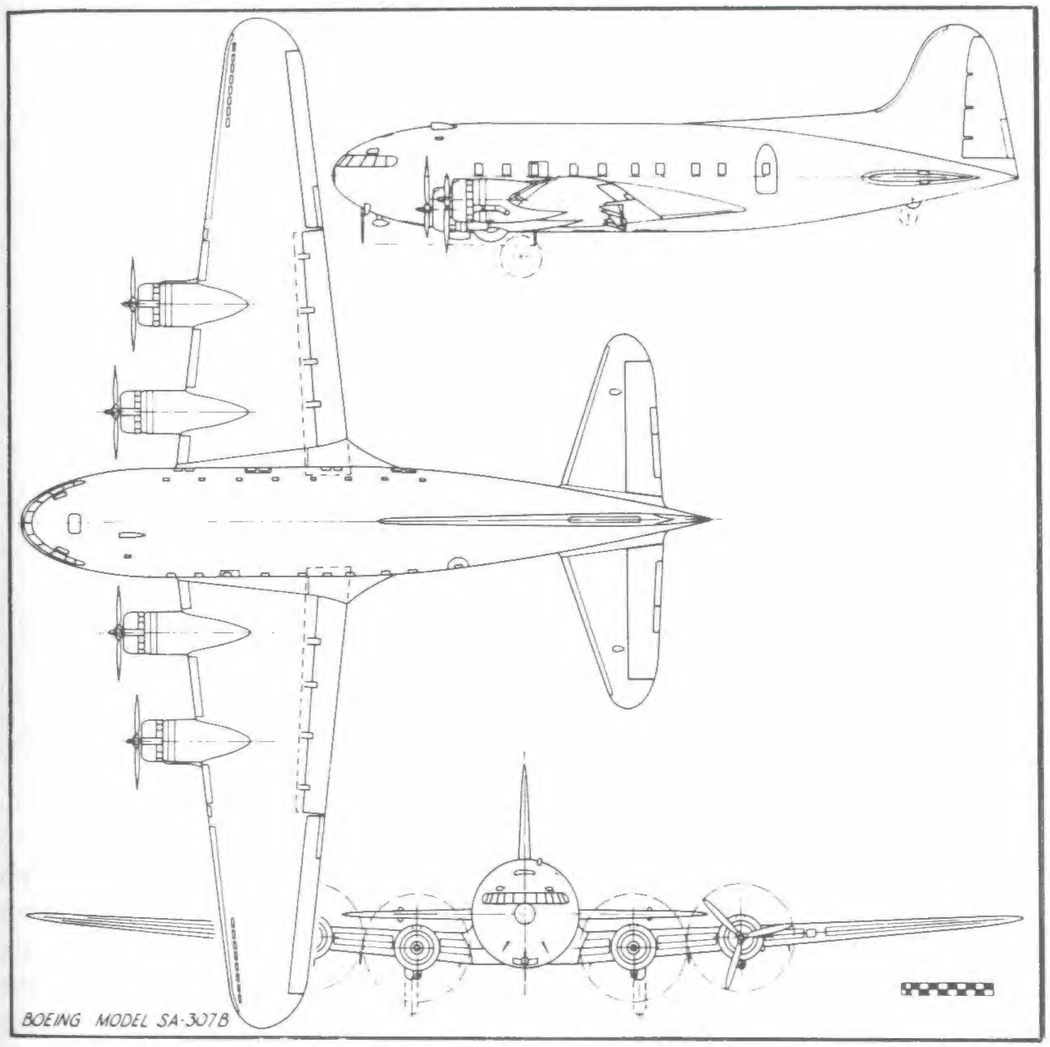
C/ns: 1996, 1998/2001
Registrations: NC 19905/19909 (NC 19906 to 1940)

• C-75 – In 1942 TWA's 307s, along with many other airliners, were drafted by the Army Air Transport Command. They were assigned the military designation of C-75, and the civil registrations were cancelled and replaced by Army serial numbers. Although military property and used for military business, the 307s were operated by TWA crews until they were sent to the factory in 1944 for reconditioning prior to return to the airlines as SA-307B-1.

Army serial numbers: 42-88623/88627

• SA-307B-1 – The SA-307B-1 was practically a new aeroplane. The original B-17C wings and nacelles were replaced with B-17G components,

After release from the Army, the C-75s were rebuilt at the factory for TWA and redesignated SA-307B-1. External differences were deletion of the external flap hinges and installation of a larger B-17G horizontal tail located 3 ft further aft. (*Photo by Peter M Bowers*)



the 900 hp Wright Cyclone engines were replaced by 1,200 hp GR-1829-G666 models, and the larger B-17G horizontal tail was installed at a point 3 ft further aft than the original. The wing tip slots were retained. The electrical system was completely revised to B-29 type and the cabin pressurization feature was deleted. Passenger capacity was increased to 38 and allowable gross weight was increased to 45,000 lb. The first conversion was flight-tested in TWA markings but with the military serial number. All five were returned to service with their original civil registration numbers, which was not common practice in the case of most drafted transports returned to civilian service.

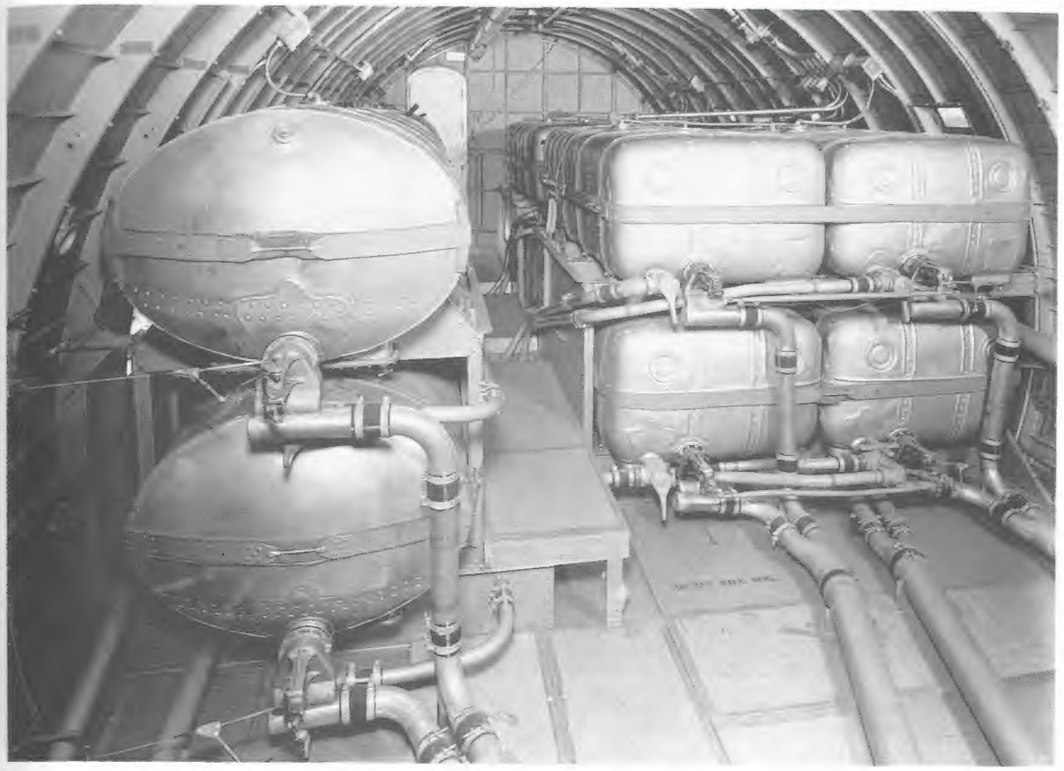
After several years in postwar service, the SA-307B-1s were put on aircoach flights as the result of a Civil Aeronautics Board ruling that airlines could not use the same aircraft for coach services that were used for first-class runs. When the ruling was changed, the Stratoliners returned to the 'plush' runs before being sold to the French airline Aigle Azur in 1951. French registrations were F-BELU, BELV, BELX/BELZ for c/ns 1998, 1996, 1999/2001.

Howard Hughes' SB-307B as delivered, with original small tail and twin-row Wright R-2600 engines under long-chord cowlings. (*Courtesy John Underwood*)

Three SA-307Bs, still with French registration but under US control, were based at Saïgon, South Vietnam, during the Vietnam war, and were unique in being the only civil aircraft allowed to fly to Hanoi, the North Vietnamese capital. One was inadvertently shot down by a US fighter due to misidentification and the other two were eventually damaged beyond economical repair.

• SB-307B – One Stratoliner, fitted with the small B-17c tail and designated SB-307B, was acquired in 1938 by the multi-millionaire Howard Hughes for an attempt on his own 3 day 18 hr record for a flight around the world, set in July of that year in a Lockheed Model 14. When his initial attempt to purchase the aircraft direct from Boeing was thwarted by the company's production commitment to two airlines, the impulsive Hughes bought control of one of the customers, TWA, and diverted the first of the six aircraft it had on order to his own use. This aircraft was distinctive in that it had the external flap hinges of the SA-307B but used 1,600 hp Wright GR-2600 Twin Cyclone engines under long-chord cowlings like those of the S-307. The normal 1,700 gal fuel capacity was increased by adding eight tanks to the cabin for an additional 2,290 gal. The outbreak of WW-II cancelled Hughes' plans for another world record attempt and the aeroplane was converted to an ultra-deluxe personal aircraft. The cabin tanks were removed to make way for accommodation for fifteen day or six sleeper

After the SB-307B was damaged by a Florida hurricane, it was sold for scrap and the new owner, David Drimmer, converted the fuselage to a luxurious cruising houseboat. (*Courtesy David Drimmer*)



Forward cabin of Howard Hughes' Boeing SB-307B, with auxiliary fuel tanks installed for planned four-stop flight around the world. (*Boeing Photo 11681-B*)

passengers in what was the most luxurious interior ever fitted to an aeroplane. At a cost of some $250,000, the furnishing included a full-size bar and buffet, full kitchen facilities, two lavatories, a ladies' powder room, panelled ceilings with indirect lighting, a speaker system for announcements or recorded music, and special air conditioning systems.

Removal of the cabin tanks and installation of an enlarged Stratoliner tail made the machine eligible for a standard licence, but it could not be certificated until standard single-row Cyclone engines were installed by Pan American Airways' shops at Brownsville, Texas, in 1947. The aeroplane was not flown at all from September 3, 1939, until May 1947. It is reported that the US Army tried to acquire the aeroplane along with the TWA 307s, but that Hughes would not release it. Hughes sold the aircraft to Texas millionaire Glen McCarthy after the war. Between them, the two owners made very little use of it. When it came on the open market late in 1963, it had accumulated a total of only 500 hours for an annual utilization of 20 hours over a 24-year period. This aeroplane was extensively damaged by a hurricane in Florida and was scrapped. The fuselage was then converted to a houseboat by an ingenious buyer.

C/n: 1997 *Registration:* NC-19904

MODEL 314 (CLIPPER, C-98, B-314) – The Model 314 was designed to meet the requirements of Pan American Airways for a transoceanic

The prototype Boeing Model 314 flying-boat with the original small single vertical tail. (*Photo by Gordon S Williams*)

transport flying-boat. Initial discussions with PAA had taken place in 1935, but the model number was not assigned until the spring of 1936, when the actual design was submitted. This gave the 'boat a later Boeing model number than the Model 307 Stratoliner, but the 'boat was started and completed before the landplane. A contract for six 314s, called 'Clippers' at the request of PAA to conform to their other flying-boats, was signed on July 21, 1936, and the first one flew on June 7, 1938. After test flying the routes, the 314 began transatlantic airmail service on May 20, 1939, and passenger service on June 28, 1939, under ATC 704. The Clippers were the last production aircraft built at Plant 1. Because of their size, final assembly took place on the launching ramp outside the factory. After launching into the adjacent Duwamish River, the flying-boats were tied to barges and taken down the river by tugboats to the test facility that had been established among the shipyards at the south end of Elliot Bay, the seaport of Seattle.

When completed, the 314 was the largest production aeroplane in regular airline service anywhere in the world, using the basic XB-15 wing and nacelles with larger engines on a conventional flying-boat hull. While sponsons had been used in place of wing-tip floats on flying-boats ever since WW-I, they were used only for the second time on an American flying-boat and for the first time on a Boeing design. The crew accommodation followed

The second vertical tail configuration for the Prototype 314 was the twin arrangement shown here. The final form was a combination of both designs. (*Boeing Photo C-141*)

Pilots' controls of the Boeing 314. Note sparcity of instruments; most power plant and fuel system instruments and controls were at the Flight Engineer's station. (*Boeing Photo 11161-B*)

XB-15 practice in providing for a flight engineer's station and crew sleeping quarters on a separate deck from the passengers. The hull was of sufficient size to permit the passenger cabin to be divided into four separate compartments, several having slightly different floor levels because of the slope of the bottom of the hull.

As originally built, the first 314 had a single vertical tail. This gave insufficient directional control and was replaced by two, one on each end of

The six-man control cabin of the Boeing 314. Pilots at the front, Radio Operator and Flight Engineer at the right, Navigator and Aircraft Commander at the left. (*Boeing Photo 11163-B*)

The second Model 314 was completed with the final triple tail. After launch onto the Duwamish River from Plant 1, it was tied to a barge and moved sideways down the river to be flown from Seattle's salt-water harbour. *(Boeing Photo)*

the horizontal tail. More area was needed, so a fixed vertical fin the size and shape of the original fin and rudder was added in the original location.

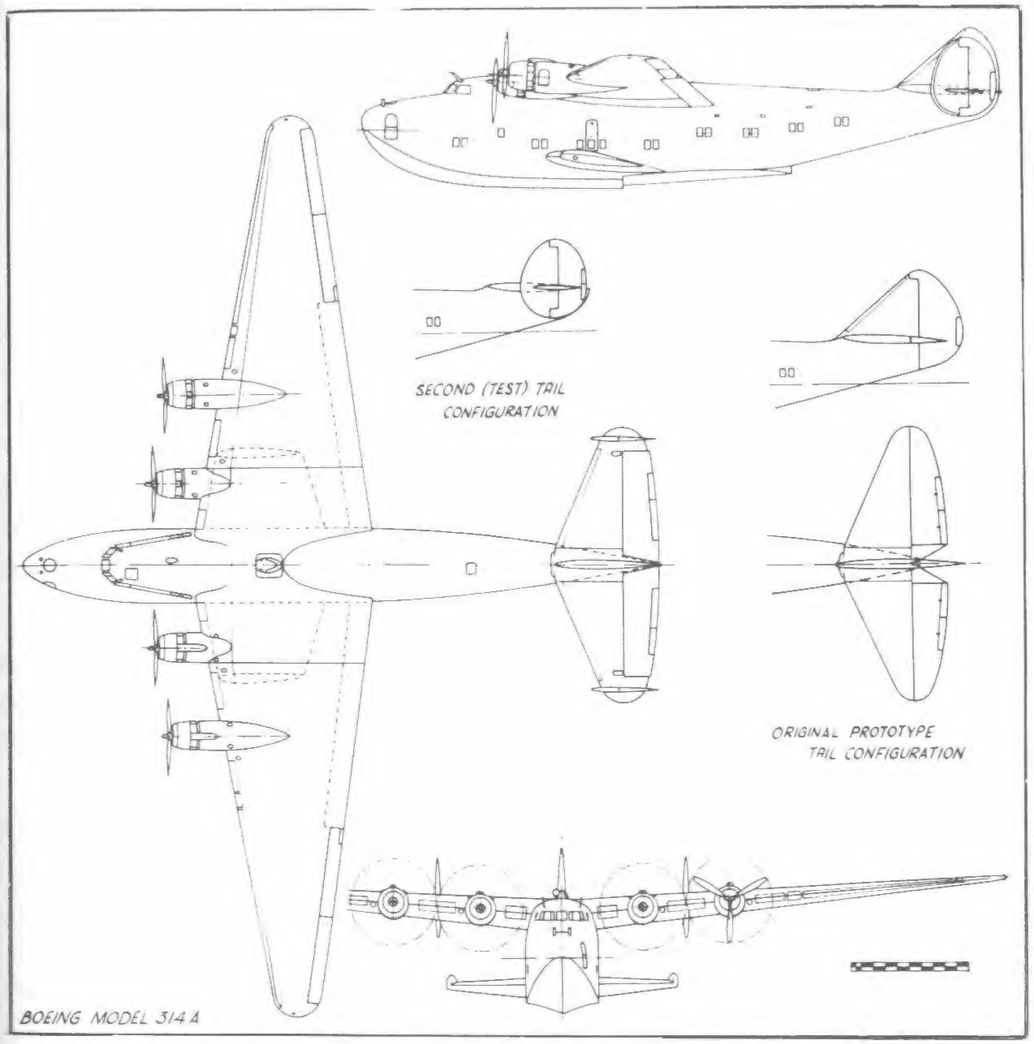
While the 314 had room for a maximum of 74 passengers and up to 10 crew members, the arrangement varied according to the nature of the flight. In sleeper configuration, only 40 passengers were carried.

Following delivery of six additional flying-boats to PAA as Model 314A, five of the original six were modified to incorporate the same improvements and were redesignated 314A. One 314 caught by the outbreak of war in East Asia escaped by flying westward to complete a flight around the world.

TECHNICAL DATA - MODEL 314

Type:	Over-water long-range transport
Accommodation:	74 passengers, 10 crew (max)
Power plant:	Wright GR-2600 Double Cyclone, 1,200 hp at 2,100 rpm at 5,400 ft (1,500 hp for take-off)
Span:	152 ft
Length:	106 ft
Height:	27 ft 7 in
Wing area:	2,867 sq ft
Empty weight:	50,268 lb
Gross weight:	82,500 lb
Max speed:	193 mph at 80,000 lb at 10,000 ft
Cruising speed:	183 mph
Climb:	565 ft/min
Service ceiling:	13,400 ft
Range:	3,500 miles

C/ns: 1988/1993 *Registrations:* NC-18601/18606

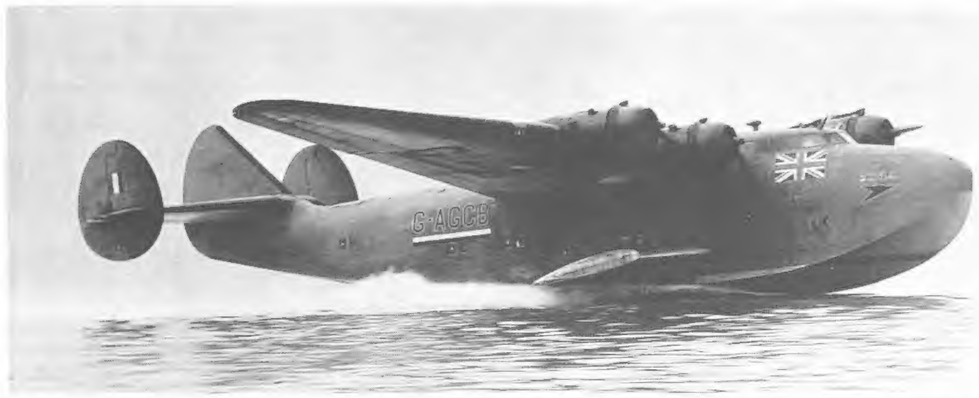


• 314A - Six additional flying-boats were built for Pan American Airways following delivery of the first six and were designated 314A because of the various improvements incorporated to improve range and performance. The first 314A flew on March 20, 1941, and all had been delivered by January 20, 1942. Improvements over the 314 included a 1,200 gal increase in fuel capacity, revised interior arrangements, and engines with take-off power increased to 1,600 hp.

C/ns	*US registrations*	*British registrations*
2081	NC 18607	G-AGBZ *Bristol*
2082	NC 18608	G-AGGA *Berwick*
2083	NC 18609	
2084	NC 18610	G-AGCB *Bangor*
2085	NC 18611	
2086	NC 18612	

WARTIME OPERATIONS

After modification of the 314s to 314A standard and the sale of the three 314As to BOAC, the size of the PAA Clipper fleet was further reduced by



Bangor, one of three Boeing 314As purchased from PAA by British Overseas Airways Corp, flying in WW-II British civil markings with camouflage. (*BOAC Photo*)

the drafting of the remaining nine into the US Army and Navy. Four of these were loaned back to PAA for its own use but were under Navy control. The three BOAC aircraft were operated on transatlantic service by the airline as civil aircraft in full British camouflage.

• C-98 – The Army's Transport Command (ATC) requistioned four of PAA's 314As and assigned them the military designation of C-98. Since ATC was not in a position to use flying-boats to the best advantage, they turned them all over to the US Navy.

• B-314 – As in the case of several other civil types acquired by the Navy during the war, the four Boeing 314As (C-98s) taken over from the Army and five additional acquired directly from PAA were not given standard naval designations but were identified merely as B- (for Boeing) 314s. They were operated by PAA crews under contract to the Navy and carried their original civil registration numbers instead of military markings. The only military aspect of their appearance was the application of standard Navy sea-grey camouflage to the top and upper side surfaces.

Four were released to Pan American for its own passenger operations

NC 18612, the last Model 314A, in US Navy camouflage as B-314 after serving briefly in the US Army as C-98 42-88622. (*Boeing Photo 97122*)

during the war while retaining their naval camouflage. The remainder were returned to the airline after the war.

The following table gives the full correlation of Model 314 civil registrations to wartime US Army and US Navy serial numbers; the three to BOAC are not included.

Civil registration	*US Army serial*	*US Navy serial*	
NC 18601 *Honolulu Clipper*		48227	To PAA
NC 18602 *California Clipper*	42-88632	99084	
NC 18603 *Yankee Clipper*		48224	To PAA
NC 18604 *Atlantic Clipper*		48225	
NC 18605 *Dixie Clipper*		48226	
NC 18606 *American Clipper*	42-88631	99083	
NC 18609 *Pacific Clipper*		48228	To PAA
NC 18611 *Anzac Clipper*	42-88630	99082	To PAA
NC 18612 *Capetown Clipper*	42-88622	99081	

POSTWAR OPERATIONS

After the war PAA resumed civil flying-boat operations only briefly before replacing the venerable Clippers with newly-available four-engined landplanes of equal range and greater speed. All of the PAA Clippers and the three BOAC 'boats were sold to new American owners in the early postwar years. These found their way into the hands of charter operators and two were lost, one in the Atlantic and one in the Pacific. Both made successful forced landings on the open sea following fuel shortage and mechanical troubles resulting from less-than-airline standards of maintenance and operation. All passengers were rescued in each case, a tribute to the widely-advertised inherent advantage of the flying-boat for overwater operation, but the flying-boats had to be sunk by gunfire because they could not be towed to port in the stormy weather prevailing at the time.

For minor inflight maintenance, the accessory sections of the Boeing 314 engines could be reached by passageways from the control cabin through the wings. (*Boeing Photo P-836*)

Chapter 7

WORLD WAR II

Military aviation was in its infancy at the outbreak of WW-1, and developed more rapidly during that four-year period than did any other branch of the military. Development of the aeroplane continued in the peacetime years at a rate greater than that of other conventional weapons, largely as a result of the demand for improved performance and efficency for competitive commerical use. As pointed out in Chapter 6, most of the basic changes in aeroplane structure and design were made first on commercial models. The Air Forces of the major powers were almost completely re-equipped with aircraft built to the new design concept by the beginning of WW-II, and only a few obsolescent designs still in service reflected the old WW-I design philosophy.

While the new designs began to evolve around 1930 and WW-II did not begin until September 1939, the WW-II period of aviation properly dates from approximately 1934, for the new concepts were well established then, and it was in that year that the specifications for many of the best-known WW-II service types were issued. Where WW-I types, because of their

Seattle Plant II was covered with a camouflage hill early in 1942, complete with city streets, houses, and parked cars. This photo, taken very late in the war, shows the camouflage still in place. Note the fading and the high visibility of the white concrete ramps now supporting B-29s instead of B-17s. (*Boeing Photo X-1229*)

small size, low performance, and simple structures, could be designed and put into production in a matter of months, this was not the case during WW-II. Structures and systems had become so complex that years were required to design, test, and get them into large-scale production. Without exception, every aircraft design that played a significant role in WW-II was a prewar design or a direct development of one. Only a handful of new designs developed entirely as a result of WW-II experience saw service before V-E day and their effect on the prevailing military situation was negligible. The prewar designs that carried the major operational load remained in production almost to the end, and were in a continual process of development and refinement that absorbed many times the engineering and flight-test hours that had been expended on the original models. While the combat life of an individual aeroplane could be reckoned at a few short weeks or possibly months, the production and service life of the basic design was determined by its growth factor – the ability of the design to take larger and more powerful engines, to carry constantly increasing military loads, and to adopt to changing tactical conditions.

Boeing production in WW-II was concentrated on three basic models: the B-17 designed in 1934 (Chapter 8), the B-29, design studies for which began in March 1938 (Chapter 9) and the Kaydet trainer, which could be traced back to the Model 203 of 1929. Other experimental designs detailed in this chapter were either not put into production or were not produced in time to become operational. Just prior to US entry into the war, Boeing built Douglas DB-7 attack bombers at Seattle. Later, Waco CG-4A cargo gliders were built at Wichita and Consolidated patrol bomber flying-boats were produced in the new Boeing Canada plant in Vancouver, B.C., which had turned out British-designed Blackburn Shark torpedo aircraft in 1938–39. Boeing B-17s, on the other hand, were built by Douglas and Lockheed while B-29s were built by Martin and Bell.

Boeing expansion in anticipation of WW-II began in 1936 with the building of Plant 2 for the B-17. As orders for this model increased, the new plant was expanded accordingly. On April 8, 1939, the Stearman plant in Wichita, Kansas, then a Boeing-owned subsidiary, was made a division of the company and its facilities were expanded for increased trainer production. However, the original Stearman model designation and serial numbering systems were retained. The development of a new patrol bomber flying-boat for the Navy, the XPBB-1, resulted in the building of a new Navy-owned plant at Renton, on the shore of Lake Washington. The changed tactical situation in the Pacific after the Battle of Midway Island in June 1942, and the successful use of land-based anti-submarine patrol aircraft in the Atlantic caused the Navy to cancel the production order for PBB-1s and transfer the Renton plant to the Army, which used it later for B-29 production. With the Seattle factory commited to B-17s and the Renton plant then under construction to be used for flying-boats, the original source of the B-29 was to be a new government-owned Plant 2 at the Wichita Division. The Seattle Division, meanwhile, took over available

The original Stearman plant photographed in November 1940, before its wartime expansion. US Army PT-17s and Navy N2S-1s are parked awaiting ferry pilots. (*Boeing-Wichita Photo*)

warehouses and office buildings in Seattle and nearby towns for the fabrication of sub-assemblies and use as training schools and storage areas. Wartime manufacture of the B-17 and B-29 by other firms is covered in Chapters 8 and 9.

Seattle employment, at 1,755 in January 1938, grew to 2,960 by the end of the year when B-17 and Stratoliner production got rolling. It was up to 8,724 in August 1940, and jumped to 28,840 after Pearl Harbor when housewives by the thousand entered industry to do their bit toward winning the war. Peak wartime employment was 44,754 in January 1945, and even included a number of midgets trained to work in tight corners and areas inaccessible to normal-sized workers.

Starting with the Y1B-17s and the Stearman-Boeing Kaydets of 1936–37 and including the few commercial models and experimental prototypes of the period, Boeing delivered a total of 19,011 aircraft to the end of 'wartime' production in June 1946, when the last B-29 was completed at Renton. This total was increased by the 6,949 B-17s and B-29s built by four other firms. B-17 deliveries ended in May 1945, but 5,092 B-29s still on order in the Renton, Wichita, Martin-Omaha and Bell-Marietta plants were cancelled soon after V-J Day. Deliveries of Boeing-designed aeroplanes by plant and sub-contractor, as well as other designs built by Boeing from June 1935, the start of Model 75 and 76 deliveries from the Wichita Plant to June 1946, the completion of B-29 production, are itemized as follows:

SEATTLE
- 6,980 B-17
- 380 Douglas attack bomber
- 12 Model 314 Clipper
- 10 Model 307 Stratoliner
- 3 XB-29
- 3 XC-97
- 3 XF8B-1
- 1 XPBB-1

Total 7,392

RENTON
- 1,119 B-29A

WICHITA
- 8,428 Kaydet
- 17 Model 73 (Excluding 61 NS-1s)
- 78 Model 76
- 1,644 B-29
- 750 CG-4A Glider
- 2 XAT-15
- 1 XA-21
- 1 XBT-17

Total 10,121

VANCOUVER
- 362 Consolidated boats
- 17 Blackburn Shark

Total 379

DOUGLAS
- 2,995 B-17F/G

LOCKHEED
- 2,750 B-17F/G

BELL
- 668 B-29, B-29B

MARTIN
- 536 B-29

Not all of the 'wartime' models are described in this chapter. Because of overlap of the historical periods by which this book is organized and the fact that some outstanding aircraft deserve chapters of their own, the following five aircraft are described in other chapters as indicated:

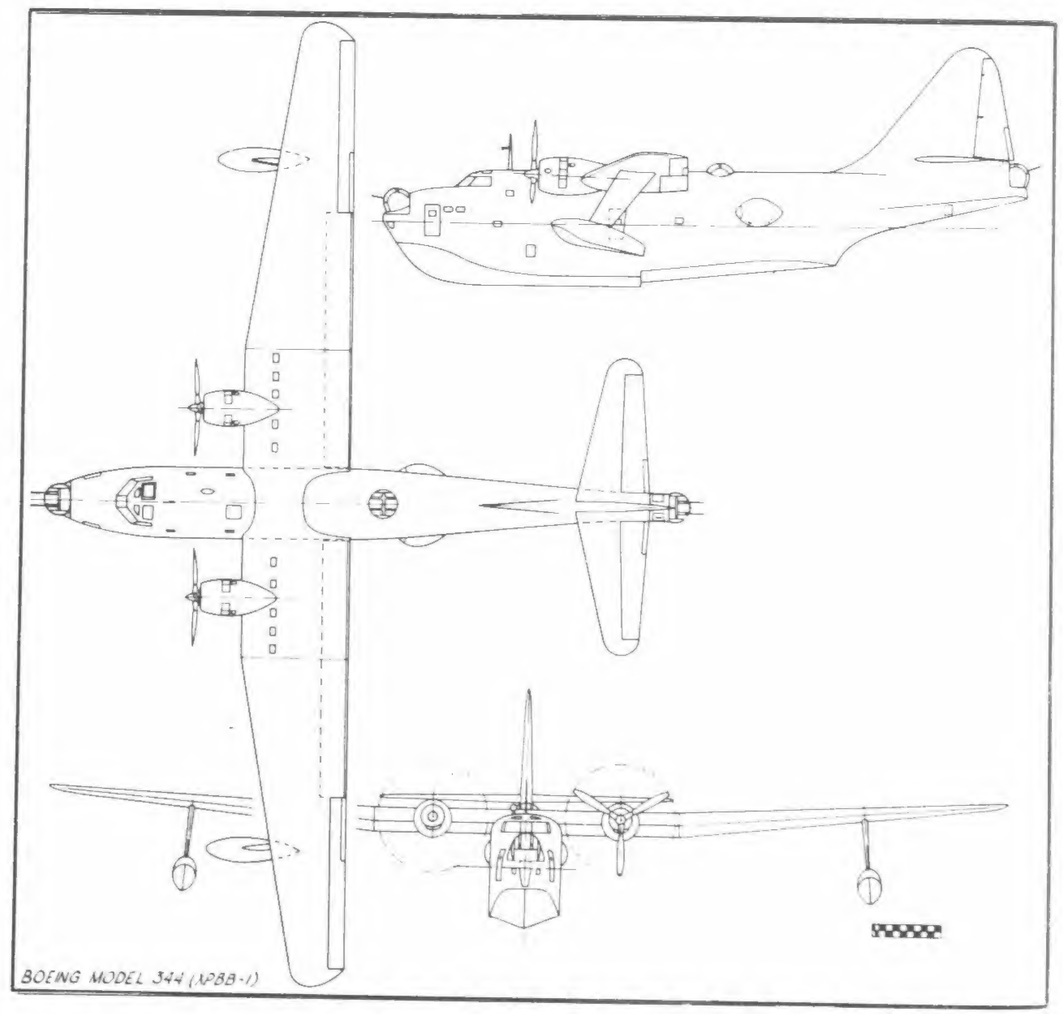
Model 299 (B-17 Flying Fortress)	Chapter 8
Model 307 Stratoliner	Chapter 6
Model 314 Flying-boat	Chapter 6
Model 345 (B-29 Superfortress)	Chapter 9
Model 367 (C-97 Stratofreighter)	Chapter 10

Wichita Plant 2, built and owned by the government for B-29 production. The original Stearman buildings (Plant 1) are in the background. (*Boeing-Wichita Photo BW-34526*)

Seattle-designed models are described first in this chapter, followed by the Stearman-Wichita designs and finally the non-Boeing designs.

MODEL 344 (XPBB-1) – The XPBB-1 was a long-range patrol bomber flying-boat of conventional construction and configuration. The outstanding feature was the unusul size for a twin-engine type. The wing, which used the newly-developed Boeing 117 aerofoil section and was essentially that used on the B-29 landplane bomber, had a span of 139 ft 8½ in, making the XPBB-1 the largest twin-engine aeroplane ever built up to the time of its first flight on July 9, 1942. Theoretical endurance was 72 hr cruising with an initial fuel load of 9,575 US gal.

The XPBB-1 was built at Plant 1 and shipped by barge to the new Renton plant at the south end of Lake Washington, which had been built by the Navy for an initial production order of 57 PBB-1s, for assembly. While the XPBB-1 was an excellent flying-boat, the military situation had changed and the Navy's anticipated requirement for flying-boats was reduced to a level that could be met by types currently in production. Consequently, the production PBB-1s were cancelled and the Navy turned the Renton plant



The single XPBB-1 (Boeing Model 344), largest twin-engine flying-boat ever built in the United States. Changing war situation cancelled production orders. (*Boeing Photo 45655*)

over to the Army for B-29 production in exchange for use of the North American Kansas City plant, which turned out land-based B-25s for the Navy as PBJ-1s.

The name of Sea Ranger was officially assigned to the PBB-1 type, but when the production order was cancelled the single prototype was referred to as The Lone Ranger by those associated with it.

TECHNICAL DATA – XPBB-1

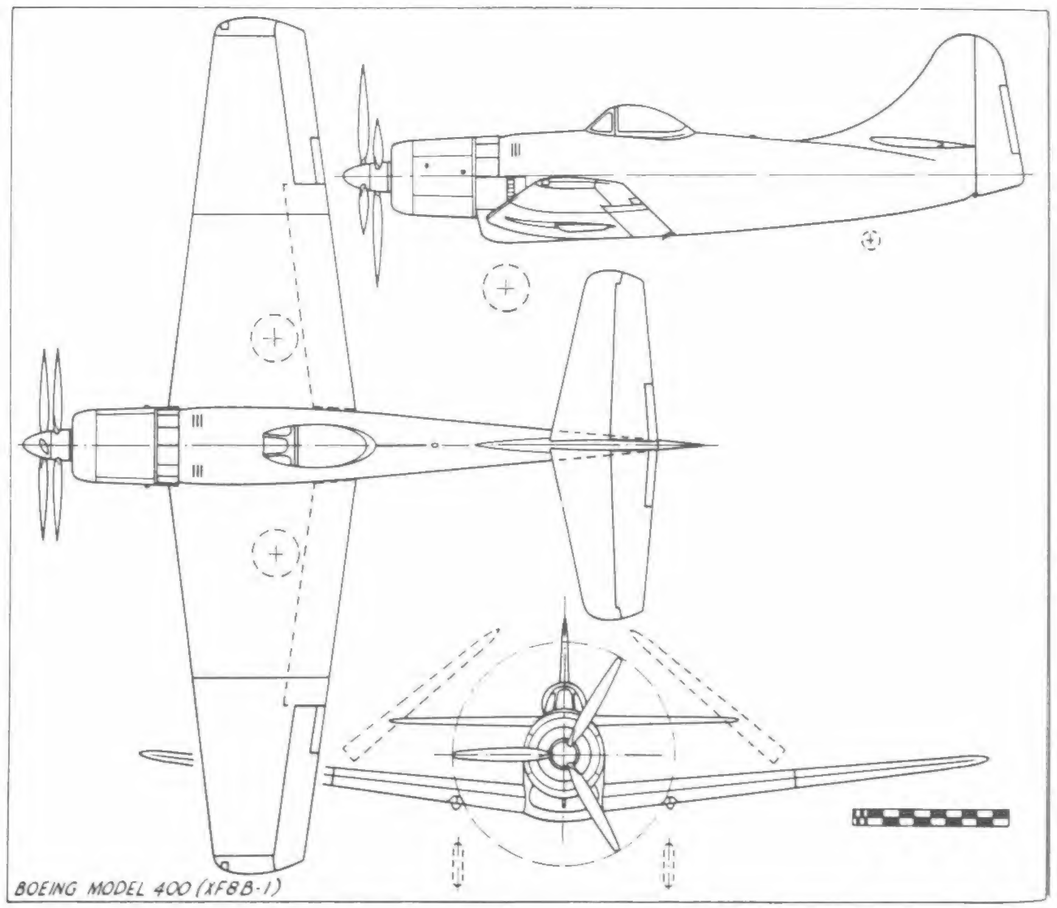
Type:	Patrol flying-boat
Accommodation:	10 crew
Power plant:	2 Wright R-3350-8, 2,000 hp at sea level to 4,000 ft
Span:	139 ft 8½ in
Length:	94 ft 9 in
Height:	35 ft
Wing area:	1,826 sq ft
Empty weight:	37,383 lb
Gross weight:	101,129 lb (JATO)
Max speed:	219 mph at 4,500 ft
Cruising speed:	158 mph
Service ceiling:	18,900 ft at 61,500 lb
Range:	4,245 miles (normal)
Armament:	Four ·50 cal MG, twenty 1,000 lb bombs (maximum)
C/n:	2129
Navy serial number:	3144 (second series)

MODEL 400 (XF8B-1) – The three XF8B-1s were the first Boeing Navy fighters since the XF7B-1 of 1933–34. Actually, the aeroplane was a multi-purpose type and not a straight fighter even though the designation had been assigned because of the single-seat configuration. Comparable Martin and Douglas single-seat Bomber-Torpedo types were originally designated BTM-1 and BT2D-1, later changed to AM-1 and AD-1, the A identifying attack. It is logical to assume that the XF8B-1 would also have been

The first of three experimental XF8B-1s (Boeing Model 400) that were developed too late for WW-II. Note use of short-lived script form of company trademark. (*Boeing Photo P-6310*)

redesignated had it been placed in production.

The XF8B-1 was the heaviest carrier-based aeroplane built up to the end of WW-II. In order to keep propeller diameter and undercarriage size within practical limits, a six-blade contra-rotating propeller was installed to



absorb the 2,500 hp of the Pratt & Whitney four-row 28-cylinder engine. Bombs or torpedos could be carried in an internal bomb bay and extra fuel could be carried in two external tanks. The undercarriage folded backward in the manner of the old Boeing Monomail, B-9, and XF7B-1, but also rotated 90 degrees so that the wheels lay flat in the bottom of the wing. The XF8B-1 was the only Boeing to use this feature, even though it was an early Boeing development. It was licensed to Curtiss in 1934 and saw wide use in the Curtiss P-36 and in the P-40 series of WW-II fame. The six ·50 calibre machine guns were mounted in the wings outside the propeller arc and the wings folded upward midway between the undercarriage and the wing tip. The first flight was made on November 27, 1944.

TECHNICAL DATA - XF8B-1

Type:	Carrier-based bomber-fighter
Accommodation:	1 pilot
Power plant:	P & W R-4360, 2,500 hp at 2,500 rpm, sea level to 5,000 ft
Span:	54 ft
Length:	43 ft 3 in
Height:	16 ft 3 in
Wing area:	489 sq ft
Empty weight:	14,190 lb
Gross weight:	20,508 lb
Max speed:	432 mph at 26,500 ft
Cruising speed:	190 mph
Climb:	3,660 ft/min
Service ceiling:	37,500 ft
Range:	3,500 miles
Armament:	Six ·50 cal MG, or six 20 mm cannon, four 500 lb or two 1,600 lb bombs in bomb bay, two 500 lb, two 1,000 lb, or two 1,600 lb bombs in external racks.
C/ns:	8484/8486
Navy serial numbers:	57984/57986 (third series)

BIPLANE TRAINERS - MODELS 70/76 - Although introduced and in production before the World War II period covered by this chapter, earlier biplanes from the prototype Model 70 to the export Model 76 are included here to make coverage of this extensive biplane family complete. Other than the 61 US Navy NS-1s (Model 73), the remainder of 78 Model 73s and all 78 Model 76s were built for export. There was only one Model 70 but there were 8,429 Model 75s.

MODEL 70 - In a bold move at the height of the world-wide economic depression that had closed many aircraft factories, tiny Stearman introduced a new two-seat biplane trainer at a time when that type was

The single Model 70, prototype of the entire Model 70–76 series, in its final configuration. The temporary US Army designation XPT-943 appeared on the forward fuselage. (*Boeing-Wichita Photo*)

considered obsolete in the civil market. However, there was a requirement from both the US Army and the US Navy for the type and Stearman sought this business. Model 70, powered by a 215 hp Lycoming radial engine, was designed and built late in 1933. It was a thoroughly traditional biplane, seemingly over-stressed at the time, and carried on the evolution of Stearman biplanes since 1927; it also drew some structural detail from the Boeing Model 203 design that had been sold to Stearman. The fuselage and tail were welded steel tubing and the wings were of wood, all fabric covered. An aerodynamic oddity was the use of a cambered, rather than the traditional symmetrical, section for the tailplane.

The noticeable innovative feature of the Model 70 was the undercarriage, with single legs replacing the familiar drag-producing and unsightly six or more struts used on other designs. Although carrying civil registration, the Model 70 was painted in the prevailing US Army blue and yellow. It was tested by the US Navy in March 1934 and by the Army, which assigned the designation XPT-943, in April. The Army deferred its trainer purchases at the time, but the Navy ordered 61 production versions, Stearman Model 73, as NS-1.

Following its military testing the single Model 70 received Memo Approval 2–516 on September 23, 1935, and was sold to a private owner in 1939. It is known to have accumulated 4,600 flying hours by late 1944.

MODEL 73 – The initial customer for the Model 73 was the US Navy, for the NS-1 (N for trainer, S for Stearman) in 1934. The Navy c/ns were assigned in two blocks, one near the end of the first Navy serial number series and the other near the beginning of the second series. The Stearman c/ns, however, were continuous for the entire 61 aeroplanes.

The first aeroplane of the second batch of US Navy NS-1 trainers with obsolete Wright J-5 engine and 30 × 5 high-pressure tyres. (*Boeing-Wichita Photo 73-6629-42*)

Other than minor structural refinements and a revised undercarriage, the major change in the NS-1 was the engine. Because it still had large stocks on hand, the Navy specified and supplied the 220 hp Wright J-5 Whirlwind engine (R-780-8) that had been out of production since early 1929. The Navy also specified the use of old-style 30 × 5 high-pressure tyres and wheels, the latter made at the Naval Aircraft Factory. Gross weight of the NS-1 was 2,680 lb and the colouring was the overall chrome yellow that had been standard for Navy primary trainers since the mid-1920s.

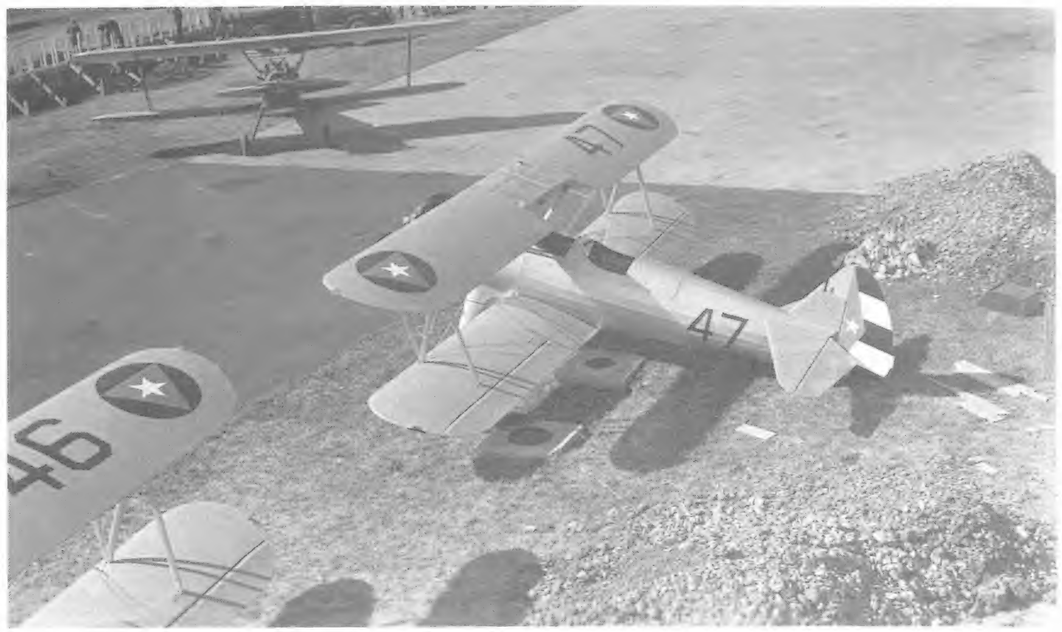
C/ns: 73001/73061
US Navy serial numbers: 9677/9717 (41), 0191/0210 (20)

MODEL 73L3 – Three Model 73L3s with 200 hp US Navy Lycoming R-680-4 engines were sold to the Philippine government in March 1936. These were followed by four more in April 1937, that differed only in using civil Lycoming R-680C-1 engines. Outwardly the Model 73L3s were indistinguishable from the contemporary Lycoming-powered Model 75 since they used the Model 75 undercarriage rather than the NS-1 type.

C/ns: 73062/73064, 73065/73068

MODEL A73B1 – The Cuban Air Force ordered seven Model A73B1 trainers. These differed from the other Model 73s in using the 235 hp Wright R-760-ET (J-6-7) Whirlwind engine instead of the Wright J-5 or the Lycoming R-680. Four were delivered in October 1939, and three in March 1940, to complete the production of 78 Model 73s.

C/ns: 73072/73075, 73076/73078



View from above of Wright-powered Cuban Model A73B1 shows exposed top of fuel tank in upper wing centre section. (*Boeing-Wichita Photo 15590*)

MODEL A73L3 – Three improved Model A73L3s for the Philippines followed the A73B1 order in July 1938, and carried immediately following c/ns.

C/ns: 73069/73071

MODEL 75 (KAYDET Trainer Series, Army PT-13, 17, 18, 27; Navy N2S) – The Model 75, given the name Kaydet, had been in production by Stearman for the Army since 1936, but the majority of production was turned out during WW-II after Stearman became a division of Boeing.

The Stearman aeroplanes officially became Boeings when the Stearman plant became a Boeing Division.

MODEL 75 – Even though nameplates and paperwork proclaimed them to be Boeings, the beloved two-wingers were almost universally called Stearman by service and civil pilots alike and even by Boeing and FAA employees, who had occasion to identify them properly in their work.

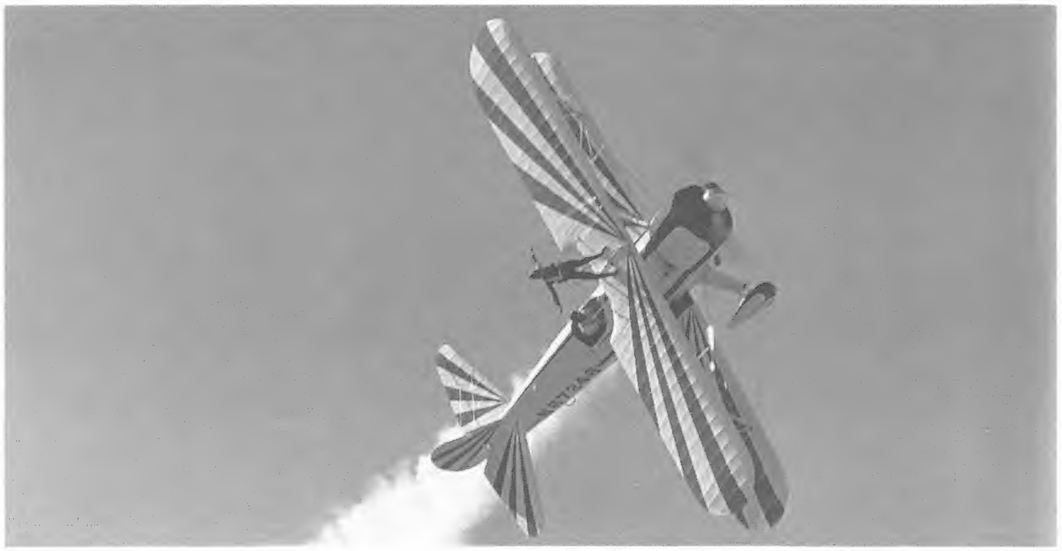
Power plant changes made to suit military interests or in consideration of the available supplies resulted in new Boeing and military designations being assigned to the basic airframe, which remained unchanged aft of the firewall and was capable of taking engines of much greater horse power. Differences between Army and Navy specifications for similar aircraft were compromised in the standardized PT-13D/N2S-5 model, many of which were delivered with the model designations and serial numbers of both services painted on the same airframe, the number of the non-using service in an inter-service transfer being cancelled at delivery but not necessarily removed from the aircraft.

The first Stearman Model 75, shown here as the X75 with Wright R-670 engine, was a refinement of earlier Models 70 and 73 and was followed by 8,428 other 75s, most of them military primary trainers. (*Boeing-Wichita Photo X75-6400-1-01*)

It is interesting to note that the military primary training school provided the last market for the military biplane, and that the Boeing Model 75, produced up to eight years after the last of the late-changing Navy's fighter biplanes had been ordered and nearly twelve years after the biplane had ceased to be a significant factor in civil aviation, was built in far greater quantity than any of the earlier biplanes that were the principal production aircraft of their time. Altogether 8,584 Stearman-Boeing biplanes in the 70–76 series were built, with spare components making the equivalent of a 10,346-plane total. Kaydet costs ranged from a high of $10,412 for the PT-13B to a low of $7,713 for the PT-27, complete. The totals of each model in the 75 series are presented in the descriptions of the separate models.

The Model 75s found wide acceptance as WW-II surplus, the majority being put to work as single-seat crop dusters and sprayers. The most common modification was the substitution of a surplus 450 hp P & W Wasp

A former PT-17 that is representative of special 'high lift' duster-sprayer conversions, using 450 hp engine and larger wings. For pilot convenience, the flight instruments are carried in the cut-out centre of the upper wing. (*Photo by William T Larkins*)



A former Army PT-17, now fitted with 450 hp engine, cowling, and wheel pants, executes a slow-roll at an air show with an aerialist held on the top wing by wires. 'Sunburst' colour scheme is almost mandatory uniform for air show aerobatic machines. (*Photo by Jim Larsen*)

Jr engine (R-985-AN-1) for the original 220 hp Lycoming, Continental, or Jacobs, and the next was the covering of the fuselage and sometimes the horizontal tail surfaces with sheet metal. In the mid-1950s several different firms introduced various modifications to the Model 75 to increase its effectiveness as a duster, usually modifying the wing tips or substituting entirely new wings. A few 75s were used in the limited field of air show and exhibition flying to which their low speed, light weight, and manoeuvrability suited them. These models were usually fitted with cowled 450 hp engines and bright Circus colour schemes and some were fitted with ailerons on all four wing panels to improve their manoeuvrability. A few 75s used as private aircraft were fitted with various home and commercially-built cockpit canopies.

In 1950, six years after the last Model 75 was built, 4,125 were still carried on the US civil air register. The high rate of attrition in crop dusting and the appearance in the late 1950s of commercial aircraft designed specifically for dusting and spraying reduced this figure to 2,028 active in 1959. The current antique aeroplane boom has resulted in many dusters being re-converted to two-seat recreational aircraft while other rebuilt abandoned hulks to bring the 1988 total of Boeing/Stearman Model 75s to 2,204.

Just as it began to lose its dominance of the agricultural field, a new career opened up for the ubiquitous Model 75. Antique aircraft had become a popular nation-wide hobby by the early 1960s, with biplanes the acknowledged favourites. Having qualified as an antique by the standards of the Antique Airplane Association virtually before it left the factory, the Model 75 became a highly-sought item. In the dusting heyday of the Model 75 a 'Stock Stearman', still with two cockpits and a 220 hp engine, was a rare bird and few were in the hands of the antiquers. As the duster conversions were replaced by newer equipment, they became available to the hobbyists

and enjoyed the unique experience of being re-converted to their original state, some even having the popular prewar blue and yellow colouring and the Army tail stripes and red-centre military markings restored.

Even though powered with a variety of 220 hp engines, there was little weight and performance difference between the different production Model 75 variants. General specifications are presented in the table below, and individual models, with their details, production histories, and military and factory serial numbers, are described in the following paragraphs.

TECHNICAL DATA - MODEL 75

Type:	Primary trainer
Accommodation:	1 pilot, 1 student, in tandem
Power plant	220 hp air-cooled radial (see text)
Span:	32 ft 2 in
Length:	24 ft ¼ in
Height:	9 ft 2 in
Wing area:	297·4 sq ft
Fuel:	46 US gal
Empty weight:	1,936 lb
Gross weight:	2,717 lb
Max speed:	124 mph
Cruising speed:	106 mph at 65% power
Climb:	840 ft/min
Service ceiling:	11,200 ft
Range:	505 miles

MODEL X75 – A new trainer prototype, the Model X75, was developed from the Models 70 and 73. Power plant was the 225 hp Wright R-670E Whirlwind. The US Army tested the aeroplane in October 1934, but again deferred its trainer purchase.

C/n:	75000
Registration:	X14407

MODEL X75L3 – After the Army tests of Model X75, the same aeroplane was fitted with a 220 hp military Lycoming R-680-3 engine and resubmitted to the Army, this time successfully. After further military and manufacturer testing, the Model X75L3 received ATC A-743 on June 24, 1939, and the registration became NC14407.

MODEL 75 (PT-13) – After the company-owned prototype was tested by the Army under civil registration, an order for 26 production trainers was placed under the Army designation of PT-13, to be powered with the Lycoming R-680-B4B 9-cylinder radial engine. The military equivalent of the civil engine was R-680-5. Deliveries were from June to the end of December 1936.

C/ns:	75001/75026
Army serial numbers:	36-2/27

The original Army trainer versions of the Model 75 were PT-13s. Improved PT-13A illustrated was produced under company Model Number A-75. (*Photo by Peter M Bowers*)

MODEL A-75 (PT-13A, B, C) – Follow-on orders for the PT-13 with minor improvements and additional instrumentation resulted in revised military designations and a new Boeing/Stearman model number.

• PT-13A – The principal change for the 92 PT-13As was installation of the Lycoming R-680-7 engine. Deliveries were from April 1937 to the end of June 1938.

C/ns: 75027/75118
Army serial numbers: 37-71/114, 37-232/259, 38-451/470

• PT-13B – A change to R-680-11 engine resulted in the Army designation of PT-13B for an additional 255 Model 75s. These were delivered in two blocks, the first 180 between October 1939 and November 1940, and the second of 75 from December 1940 to April 1941. Six were converted at random to PT-13C.

C/ns: 75119/75298, 75847/75921
Army serial numbers: 40-1562/1741, 41-787/861

What appears to be almost the entire production of PT-13As on the flight line at Randolph Field, Texas, in 1938. (*USAF Photo*)

With a cowled Wright R-760 engine and a wing-mounted machine-gun, the Venezuelan Model A75B4 differed outwardly from the similar Venezuelan Model 76B4 only in the retention of trainer-type cockpits and the absence of a rear-cockpit machine-gun. (*Boeing-Wichita Photo BW-133*)

• PT-13C – Six PT-13Bs were modified for night and instrument flying by the installation of navigation and cockpit lights, battery, and an instrument hood over the rear cockpit. The only known Army serial numbers are 40-1620 and 41-853.

MODEL A75B4 – Five special militarized 75s for Venezuela, powered with

Because of an impending shortage of Lycoming and Continental engines, Jacobs engines were used in the 150 US Army PT-18s, the only Model 75s to use this engine. (*Photo by Charles Shuler*)

the 320 hp seven-cylinder Wright R-760-E2 engine. Delivered in November 1941, with c/ns 752682/752686.

MODEL A75J1 (PT-18) – The original Army order for PT-17s (Model A75N1) was followed by contracts for an additional 150, identical except for the installation of a seven-cylinder Jacobs R-755-7 engine. The production of Jacobs engines was diverted to other Army aircraft and no further Model 75s were produced under the PT-18 designation.

C/ns:	75449/75598
Army serial numbers:	40-1892/2041

• PT-18A – Six PT-18s were equipped for night and instrument flying by equipment changes identical to those on the PT-13C. Known Army serial numbers 40-1906, 1909, 1934.

MODEL A75L3 – A total of 43 export and civil equivalents of the Army PT-13, powered with the Lycoming R-680-B4D, were built in 1940 and 1941 for the following users:

C/ns	*Number built*	*Users*
75599/75618	20	Brazil
75619/75621	3	Venezuela
751422/751425	4	Parks Air College
752570/752581	12	Philippines
752687/752690	4	Venezuela

MODEL A75L5 –Two NS2-4s (Navy serial number 37901 and 55759) were obtained from war-surplus stocks in November 1946. These were completely rebuilt and fitted with 190 hp six-cylinder Lycoming 0-435-11 engines for the Republic of China. The relatively small high-speed engine, which had been installed at customer request, was not suitable to the basic aeroplane, so the 20 additional war surplus N2S-3s and PT-17s ordered for

Two Model A75L5s were postwar conversions of N2S-4s (Model A75N1) fitted with 190 hp Lycoming O-435 engines at the request of the Chinese government. (*Boeing–Wichita Photo BW-37147*)

Twelve PT-17s (Model A75N1) were fitted with electrical systems and additional instrumentation for instrument training as PT-17A. Note blind flying hood over rear cockpit. (*Photo by Logan Coombs*)

conversion were procured and rebuilt but were fitted with Continental R-670-4 engines as Models A75N1 and B75N1. New Boeing serial numbers were not assigned to these aeroplanes, and only the two Lycoming-powered models acquired new model designations.

MODEL A75N1 (PT-17, 17A, N2S-1, -4) – This model, produced for both Army and Navy, was structurally identical to the PT-13A except for a change to the seven-cylinder Continental R-670-5 engine for the Army models and the R-670-4 for the Navy. With a nearly identical model in quantity production for both services, inter-service exchanges became frequent; for example, large blocks of PT-17s built for the Army were delivered to the Navy to meet an immediate Navy requirement. This loan was later repaid by diverting Navy N2S-1s, complete with Navy-designated engines, to the Army. Model A75N-1 production totalled 3,769 for the two services, making it the largest single production version of the series. Deliveries to the US Army began in March 1931, and continued until January 1943. Delivery of equivalent US Navy N2S-3s was completed in June 1943.

• PT-17 – Models in production up to the early months of 1942 were delivered in the colour scheme standard for Army trainers since 1928 – trainer blue fuselages and struts with chrome yellow wings and tail surfaces. Models delivered after April 1942 were painted silver overall. Army inspectors accepted 2,942 PT-17s at the factory, not counting conversions or models for which the Army serial numbers had been cancelled upon transfer to the Navy.

C/ns	*Army serial numbers*	*Remarks*
75299/75448	40-1742/1891	
75622/75846	41-862/1086	
751426/752569	41-7867/9010	

Preview of the Kaydet's postwar career. An Army PT-17B dusting marshland near a US Air Base in Italy to control mosquitoes. (*Boeing-Wichita Photo*)

752691/752812	41-25202/25323	R-670-4 in 41-25729 and on
752819/752878	41-25324/25383	41-25737/25740, 25748, 25802/
752885/752968	41-25384/25467	26251 cancelled and airplanes
752975/753233	41-25468/25726	redesignated N2S-4 for Navy
753249	41-25742	with Navy serial numbers
753570/753577	41-25760/25767	
753725/753758	41-25768/25801	
753348	41-25741	R-670-4, Loan to Cuba
753349/753353	41-25743/25747	
753334/753338	41-25727/25728	R-670-5, Loan to Bolivia
	41-25729/25731	R-670-4, Loan to Bolivia
753339/753343	41-25732/25736	R-670-4, Loan to Paraguay
753451/753455	41-25749/25753	
753492/753493	41-25754/25755	R-670-4, Loan to Colombia
753566/753569	41-25756/25759	
754059/754208	42-15896/16045	R-670-4, Loan to China
754538/754539	42-16375/16376	R-670-4, Loan to Guatemala
754658/754660	42-16495/16497	R-670-4, Loan to Colombia
754808/754810	42-16645/16647	
754881/754886	42-16718/16723	
754209/754436	42-16046/16273	R-670-4, Original order for
754440/754537	42-16277/16374	2,200. 42-16724/16845 cancel-
754540/754657	42-16377/16494	led and aeroplanes redesignated
754661/754807	42-16498/16644	N2S-4 for Navy with Navy
754814/754880	42-16651/16717	serial numbers
754811/754817	42-16648/16650	R-670-4, Loan to Dominican Republic
754437/754439	42-16274/16276	R-670-4, Loan to Cuba

• PT-17A – The original order for PT-17As called for the modification of 12 random PT-17s of the 1940 order to night and instrument trainers with the same equipment used on the PT-13C. The eventual total was 136.

• PT-17B – Three PT-17s of unknown serial numbers fitted with a dusting hopper in the front cockpit for mosquito control in swamplands near Army air bases.

• PT-17C – A single PT-17 fitted with standardized A-N equipment as part of a campaign to achieve inter-service standardization of certain types of aircraft. Work with the PT-17C resulted in the Model E-75 (PT-13D/N2S-5), which could be used by both services without change.

• N2S-1 – The US Navy had used earlier versions of the Model 75, the Model 73, under the Naval designation of NS-1. Differences in the power plant, equipment, and structural details of the later Model 75 justified the assignment of a new Naval model designation, N2S-1. Subsequent engine changes in the basic Model 75 resulted only in changes to the dash number in the Naval designation even though the changes were significant enough to result in revised Boeing model numbers. The initial Navy order for Model 75s was for 250 machines, some examples of which were diverted from Army PT-17 contracts and delivered with Army colouring. Standard Navy colouring for primary trainers from the late 1920s was chrome yellow overall. Deliveries September 1940–February 1941.

C/ns: 75922/751171 *Navy serial numbers:* 3145/3394

• N2S-4 – An additional 577 Continental-powered Model 75s were ordered by the Navy with later R-670-4 engines, which justified a designation change. The first 99 were diverted from Army PT-17 orders and were delivered with R-670-5 engines. The last 122 were cancelled.

C/ns	*Navy serial numbers*	*C/ns*	*Navy serial numbers*
753234/753248	27960/27974	753494/753565	30055/30126
753250/753333	27975/28058	753581/753600	30127/30146
753354/753404	29923/29973	753446/753450	34097/34101
753445	29974	753578/753580	34107/34109
753406/753444	29975/30013	753601/753602	34110/34111
753344/753347	30014/30017	753603/753714	37856/37967
753405	30018	753715/753724	37978/37987
753456/753491	30019/30054		

MODEL B-75 (N2S-2) – The initial Navy order for N2S-1s was followed by one for 125 similar aircraft powered with the Lycoming R-680-8 engine, the difference being sufficient to justify the use of a different dash number in the Navy aircraft designation. Deliveries April–October 1941.

C/ns: 751297/751421 *Navy serial numbers:* 3520/3644

MODEL B-75N1 (N2S-3) – An additional 1,875 Navy trainers identical to the N2S-1 (Model A75N-1) except for installation of a later Continental R-670-4 engine.

C/ns	*Navy serial numbers*
751172/751296	3395/3519
752582/752681	4252/4351
756409/756608	05235/05434
756609/656608	07005/08004
757609/758058	37988/38437

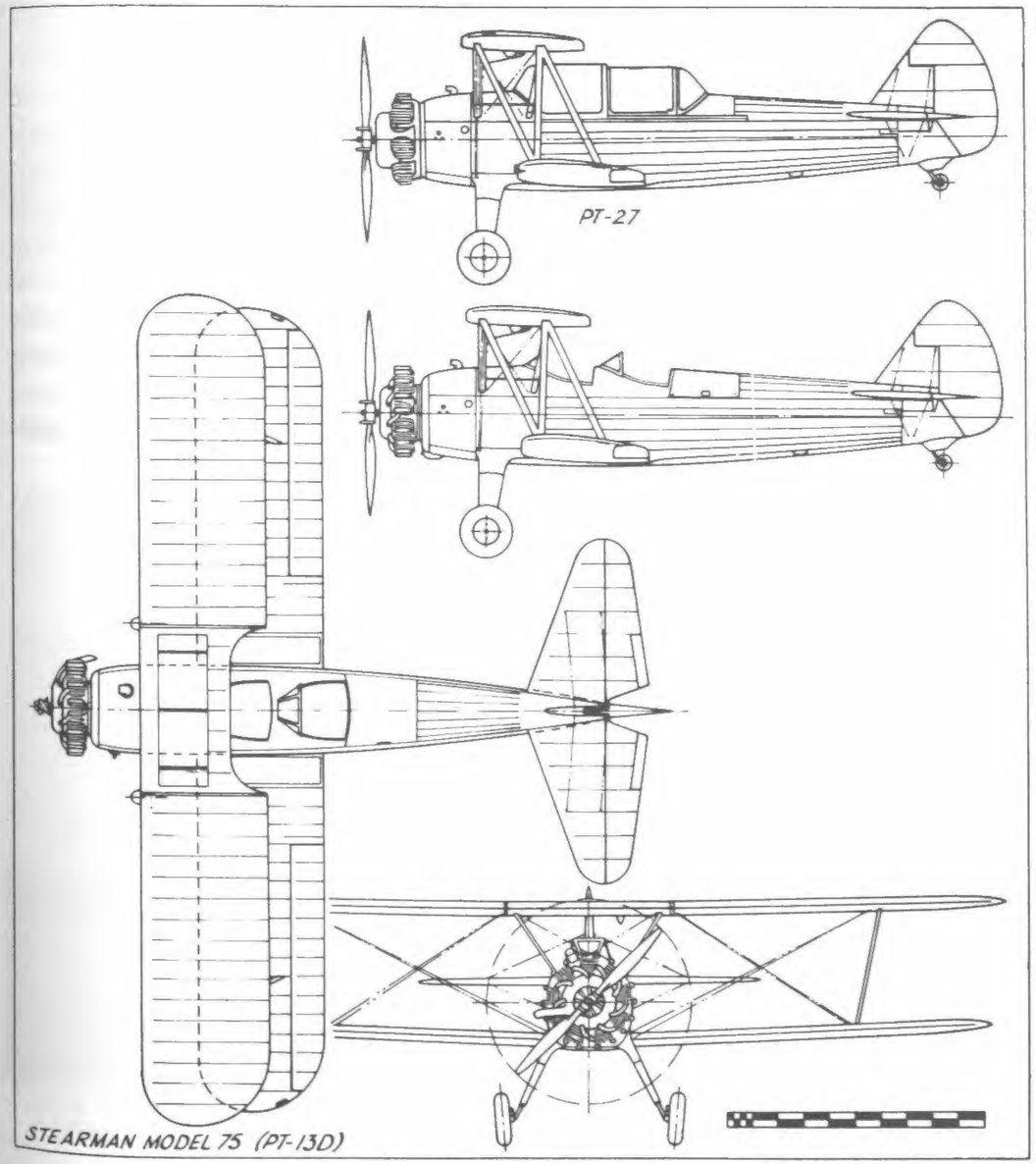
Navy N2S-2 (Model B-75) was similar to Army PT-13 with Lycoming engine. Navy colouring was yellow overall; contemporary Army models had blue fuselage, struts, and fittings. (*Boeing-Wichita Photo*)

PT-27s (Model D75N1) were special winterized versions of the PT-17 for Canada. Note modified nose cowl on engine. This particular machine was fitted with enclosed cockpits. Colour overall yellow. (*Boeing-Wichita Photo BW-3940*)

Silver-painted US Navy N2S-5 (Model E-75) fitted with winter canopy developed for RCAF PT-27. (*Photo by Charles Sheetz*)

MODEL D-75N1 (PT-27, RCAF Kaydet) – While carrying a US Army designation, these 300 aircraft were intended solely for the use of the RCAF. Since they were purchased with Lend-Lease funds, they had to have a designation appropriate to equivalent aircraft in the procuring organization, in this case the Army Air Corps. With the Continental R-670-5 engine, they were similar to the PT-17 but winterization features for Canadian operation resulted in the new designation of PT-27. One was tested with an enclosed canopy over both cockpits, ut this did not become a widely used feature. PT-27s were chrome yellow overall. Deliveries February–October 1942.

C/ns	*Army serial numbers*	*RCAF serial numbers*
753759/753790	42-15570/15601	FD-968/999
753791/754049	42-15602/15860	FJ-741/999
754050/754057	42-15861/15868	FK-100/107
754058 (Special)	42-15869	FK-108



Model E-75, the first US military aircraft to achieve complete Army-Navy interchangeability under dual designation of PT-13D/N2S-5. This machine carries designation of both services and is painted contemporary Army silver. Navy models in postwar service reverted to standard overall yellow colouring of Navy trainers. (*Boeing-Wichita Photo*)

MODEL E-75 (PT-13D/N2S-5) – This was the standardized model with Lycoming R-680-17 engine that could be used without change by both services. Colour was all silver, and the military serial number and designation were painted on to reflect the particular service that was going to use the aircraft. The first order for the combined model was for 150 machines, with delivery beginning in July 1943. This was followed by two others for a total of 1,768 built up to the V-J Day cancellations. Boeing completed the last one for its own use, and after fifteen years of service as a company photo plane it was presented to the Air Force Museum of Wright-Patterson Air Force Base, on display in prewar Army colouring.

C/ns	*Army serial numbers*
755009/755158	42-16846/16995
755220/755226	42-17057/17063

This Canadian-registered spray plane was built as Model E-75 (PT-13D/N2S-5) but is licensed as an A75N1 with float installation and increased power that makes it virtually a Model 76. (*Photo by John F McNulty*)

755243/755258	42-17080/17095
755260/755264	42-17097/17101
755278/755297	42-17115/17134
755313/755345	42-17150/17182
755347/755353	42-17184/17190
755363/755382	42-17200/17219
755390/756026	42-17227/17863
49-1458/1490	New USAF serials assigned to PT-13D/N2S-5
51-16084, 16805	rebuilds for MDAP nations. C/ns unknown
	Navy serial numbers
755129/755219	61037/61097
755227/755242	61105/61120
755259	61137
755265/755277	61143/61155
755298/755312	61176/61190
755346	61224
755354/755362	61232/61240
755383/755389	61261/61267
758059/758231	38438/38610
758232/758731	43138/43637
758732/758808	52550/52626

MODEL 75 POSTWAR IDENTITY PROBLEMS

Before World War II the power plant used in a basic design that had several power plant options usually determined the designation of the variant, as Boeing Model 203, 203A, 203B, etc. In military aircraft, different engines in

A Venezuelan Model 76B4 with smooth cowling around a 320 hp Wright R-760-E2 engine. Note wing and rear cockpit machine-guns and partial canopy between the cockpits. (*Boeing-Wichita Photo BW-139*)

the same airframe required separate model designations, as the US Army PT-13, PT-17, and PT-18.

When Boeing/Stearman Model 75s came on the surplus market after the war they received civil licences under their proper Boeing Model 75 sub-designations even though they were popularly identified by their former military designations. The subsequent changes of power plant that frequently took place did not alter those designations as they had done before the war. For example, say that one each Boeing Model A-75 (PT-13A), Model A75N1 (PT-17), and Model A75J1 (PT-18) were all fitted with 450 hp P & W Wasp Jr engines and crop dusting equipment that made them identical in every detail. In spite of this, they did not share a common identity, either old or new; they were still an A-75, an A75N1, and an A75J1, each with modifications.

Similarly, when former agricultural conversions of various Model 75s were restored to their original two-seat configurations for recreational flying, many received power plants other than their original models. Putting a 220 hp Lycoming into a former PT-18 that used a Jacobs did not make an A75 (PT-13A) of it even though the owner might call it such and even paint that designation on it. It was still a Boeing Model A75J1 according to FAA paperwork.

Identification of postwar civil Model 75s in the field cannot be determined from such outstanding external details as engines and markings; it is necessary to examine the paperwork and nameplate in the cockpit.

MODEL 76 – This was an export version of the Model 75 with armament and engines in the 320–400 hp range for use as combat trainers and light attack duties. One or two fixed forward-firing .30-calibre machine-guns could be mounted in the lower wings outboard of the propeller and a single flexible .30-calibre gun could be mounted in the rear cockpit. Up to 120 lb of bombs could be carried on a rack under the belly. Other than the larger and fully-cowled engines, greater fuel capacity, and armament provisions, the Model 76 was structurally identical to the Model 75. One external identification detail was the partial canopy between the cockpits that reduced slipstream buffet for the rear gunner.

All of the Model 76s were exported and none ever appeared on the US civil register. The Model 76s are listed here in alphabetical/numerical order of their Stearman designations, which, like the Models 73 and 75, do not match the sequence of production. The prefix S could be added to any Model 76 designation to identify seaplane versions on Edo Model 38-3430 twin floats.

MODEL 76B4 – Five Model 76B4s with 320 hp Wright R-760-E2 engines were delivered to Venezuela in November 1941. Three machine-guns were installed but no bomb rack. In spite of the low model designation number, the Venezuelan aeroplanes were the last Model 76s delivered.

C/ns: 76074/76078

A Model S76D1 for the Argentine Navy. Model 76s fitted with the Pratt & Whitney Wasp Jr engine could be identified by the bump cowling. (*Boeing-Wichita Photo*)

MODEL 76D1 – The distinguishing detail of Model 76s powered with Pratt & Whitney engines was the 'bump' cowling, as seen on the ten 76D1s delivered to the Argentine Navy in June 1936. These used the 320 hp Wasp Jr engine and were fitted with three machine-guns and bomb racks. Three more went to the Philippines in March 1937, and a final six went to Argentina in August 1937.

C/ns: 76001/76010, 76044/76049 (Argentina)
76011/76013 (Philippines)

MODEL 76D3 – A total of 24 Model 76D3s was delivered to the Philippines. The first six, with 400 hp Wasp Jr engines, delivered in September 1938, had only one wing gun and no bomb racks but carried additional fuel and had provision for an aerial camera. The following 18, delivered by September 1939, were similar but had no camera.

C/ns: 76050/76055, 76056/76073

MODEL A76C3 – Fifteen Model A76C3s were delivered to the Brazilian Air Force between May and July 1937. Power was the 420 hp Wright R-975-E3 (J-6-9) engine and only one wing gun was carried; an additional 30 gallons of fuel were carried in outboard wing tanks.

C/ns: 76014/76028

MODEL B76C3 – Fifteen Model B76C3s followed the A76C3s to Brazil between July and October 1937. These differed from their predecessors in being fitted with Fairchild K-3B aerial cameras.

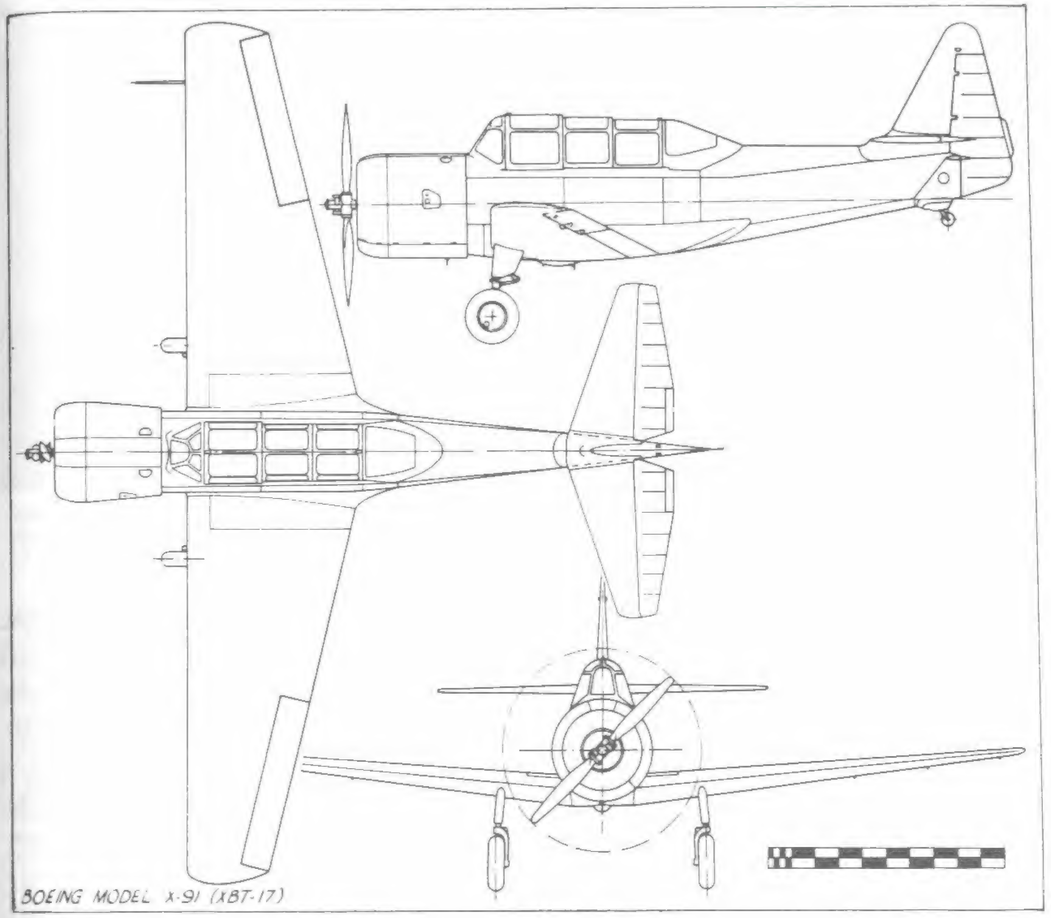
C/ns: 76029/76043

Stearman's first monoplane design after a decade and a half of traditional biplanes was Model X-90, intended as a primary trainer when fitted with 220 hp Lycoming engine. (*Boeing-Wichita Photo X90-64030*)

MODEL X-90/91 (XBT-17) – Although carrying an earlier model number than the X-100 (XA-21), the Model 90 was completed nearly two years later. It was designed and built at a time when the military training programme was expanding rapidly and the United States was faced with an aluminium shortage, so every attempt was made to use non-strategic materials. The wings and tail surfaces were of wood, with the fixed surfaces plywood covered. The forward section of the fuselage was steel tube. Only the aft portion of the fuselage was semi-monocoque aluminium.

The basic design was for a two-purpose aeroplane. When fitted with the 225 hp Lycoming R-680-B4D engine it was a primary trainer (X-90) and became a basic trainer (X-91) when a 400 hp P & W R-985 T1B2 engine was installed. The Army bought the single P & W powered prototype as

When fitted with a 450 hp P & W Wasp Jr engine, the Model X-90 became a basic trainer, Model X-91. The Army bought the 450 hp version as XBT-17. (*Boeing-Wichita Photo*)



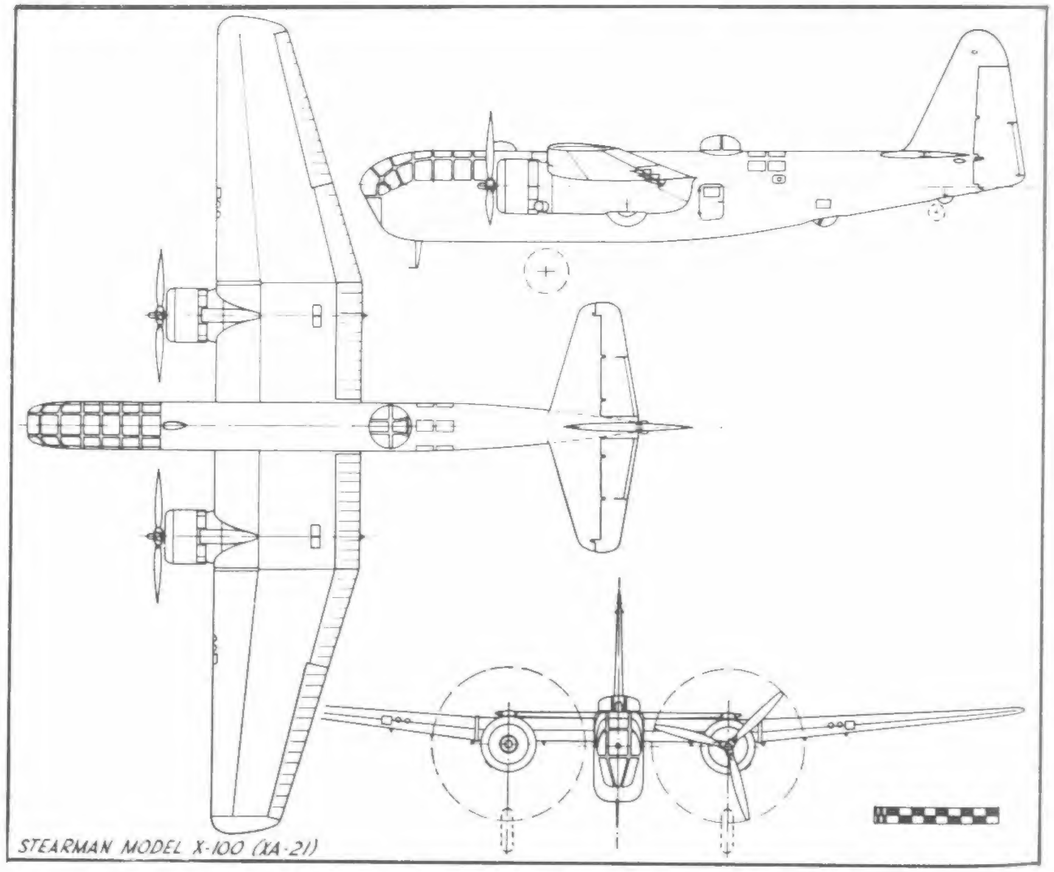
XBT-17 in January 1942. No production orders were placed for new composite-construction basic trainers because the aluminium shortage was overcome and more BT models already in production were ordered.

TECHNICAL DATA - XBT-17 (Model X-90 in parentheses)

Type:	Basic trainer
Accommodation:	Two crew in tandem
Power plant:	P & W R-985-AN-1 450 hp (Lycoming R-680-B4D 225 hp)
Span:	35 ft 9in
Length:	27 ft 9 in (28 ft 6½ in)
Wing area:	200 sq ft
Empty weight:	3,080 lb (2,101 lb)
Gross weight:	4,150 lb (2,810 lb)
Max speed:	190 mph (140 mph)
Cruising speed:	160 mph (115 mph)
Climb:	1,300 ft/min (800 ft/min)
Service ceiling:	20,000 ft (15,000 ft)
C/n:	90000
Registration:	X-21924 (X-90)
Army serial number:	42-8726 (X-91)

The XA-21 (Model X-100) in its original form with smooth-contour nose. The Stearman trademark and the designation X-100 appear on the nose and the 'Boeing Bug' and the words 'Stearman Aircraft Division' appear on the fin. (*USAF Wright Field Photo 63667*)

MODEL X-100 (XA-21) - The Stearman Company had undertaken the design of a new twin-engine light bomber for a US Army attack aircraft competition and completed it after becoming a Boeing division. The new model, designated XA-21 by the Army, was delivered in September 1939. Normal crew seating was for three, a bombardier, the pilot, and a radioman/gunner, but an additional crew member could be carried. The



XA-21 was a multiple milestone for the Stearman division, in that it was not only the first twin-engine design turned out in the plant, but the first all-metal structure and the first monoplane. It incorporated other features new to the industry at large, too, including electrically-actuated retractable undercarriage, integral fuel tanks, fully-feathering constant-speed propellers, and sealed compartments in the outer wing panels, central fuselage, and empennage for flotation in case of forced landing in water.

In the interest of streamlining, the original nose contour made an unbroken line with the top of the fuselage, the pilot looking forward through the bombardier's station as on the later B-29. However, this was soon modified to the standard step-down windshield configuration of contemporary transports and bombers. The power plant was the new and experimental Pratt & Whitney R-2180-S1A1-G, normally rated at 1,150 hp at 2,350 rpm but capable of delivering 1,400 hp at 2,500 rpm for take-off. This engine was not developed further and no other aircraft used it.

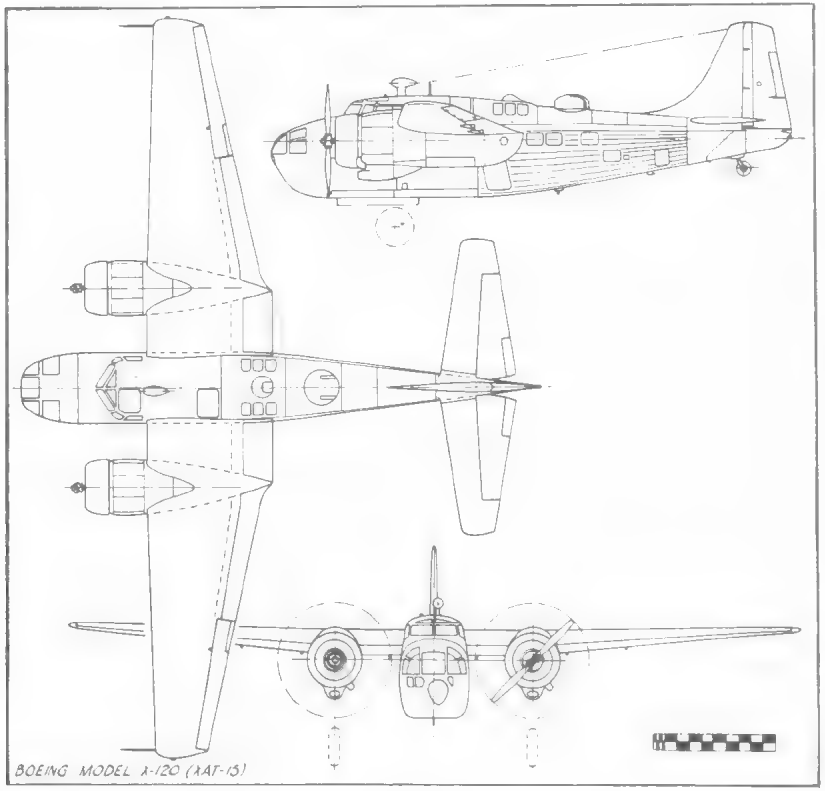
TECHNICAL DATA - XA-21

Type:	Attack bomber
Accommodation:	Three crew in tandem
Power plant:	P & W R-2180-7, 1,150 hp at 7,000 ft
Span:	65 ft
Length:	53 ft
Height:	14 ft
Wing area:	607 sq ft
Empty weight:	12,760 lb
Gross weight:	18,230 lb
Max speed:	257 mph at 5,000 ft
Cruising speed:	200 mph
Service ceiling:	20,000 ft
Range:	1,200 miles
Armament:	Six ·30 cal MG, 2,700 lb bombs
C/n:	100000
Army serial number:	40-191

The XA-21 after factory modification of the nose to incorporate standard stepped windshield giving the pilot a view over instead of through the bombardier's station. (*Boeing-Wichita Photo*)

The first of two XAT-15 bomber crew trainers (Boeing Model X-120), built to use non-strategic materials at a time of critical aluminium shortage early in WW-II. (*Boeing Photo P-23242*)

MODEL X-120 (XAT-15) - Two XAT-15s, named Crewmaker, were built as Stearman entries in a 1942 bomber-trainer competition, and because of the prevailing aluminium shortage were of composite construction. The fuselage was welded steel tubing, fabric covered, and the tailplane, fin, and wing were of wood with plywood covering. The XAT-15s were complete

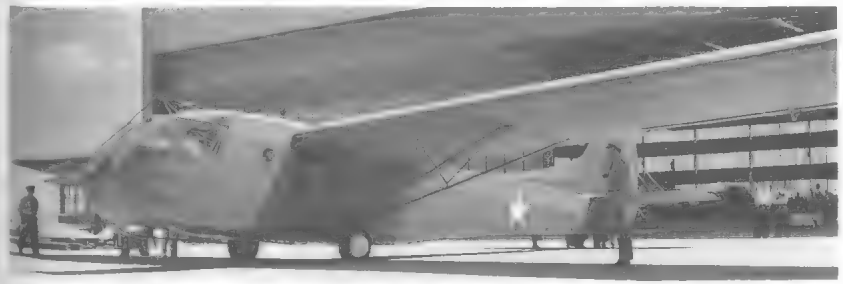


'Baby Bombers' intended to give integrated training to an entire light bomber crew consisting of bombardier, pilot, co-pilot, and gunner. Production contracts for 1,045 AT-15s, with 325 to be built by Bellanca and 360 by McDonnell, were cancelled when the Army decided against composite construction for advanced trainers. The funds allocated to the AT-15 programme were transferred to the all-wood Fairchild AT-21, with Bellanca and McDonnell sharing in the production of the twin-engine bomber-trainer.

TECHNICAL DATA - XAT-15

Type:	Bomber-trainer
Accommodation:	Bombardier, pilot, co-pilot, radioman/gunner
Power plant:	P & W R-1340-AN-1 550 hp
Span:	59 ft 8 in
Length:	42 ft 4 in
Height:	13 ft 1 in
Wing area:	457 sq ft
Empty weight:	10,640 lb
Gross weight:	14,355 lb
Max speed:	207 mph at 5,000 ft
Cruising speed:	185 mph
Climb:	10,000 ft in 11·9 min
Service ceiling:	18,900 ft
Range:	850 miles
Armament:	One ·30 cal MG, ten 100 lb bombs
C/ns:	120000, 120001
Army serial numbers:	41-23162, 23163

WACO CG-4A - The Cessna Aircraft Company of Wichita, Kansas, was one of sixteen manufacturers chosen to mass-produce the Waco CG-4A troop carrying glider. However, Cessna sub-contracted its entire order of 750 gliders to the Wichita Division of Boeing, which literally built them in the aisles of the new Plant 2 while it was tooling up for B-29 production. No Boeing model number was assigned to the Waco design nor were Boeing



The new Wichita Plant 2 built a total of 750 Waco CG-4A troop gliders on a sub-contract from the nearby Cessna Aircraft Company. (*Boeing-Wichita Photo BW-4129*)

serial numbers used on the airframes produced. The fuselage was of welded steel tube construction, with a hinged-up nose that allowed a jeep or field gun to be rolled inside. The wings and tail were of wood, and the entire framework was fabric covered. Detachable landing gear was used for training flights and in areas where they could be used during landings. For most military missions, the wheels were dropped following take-off and the landing was made on skids. A variety of twin and four-engine aircraft were used to tow the CG-4As, but the most widely used was the Douglas C-47. Unlike some surplus military aircraft, the CG-4As were not approved for standard or limited postwar civil licences, but this did not hinder the sale of surplus gliders. The complete aircraft came in three large packing cases, and the customers bought the combination, throwing the glider away and using the cases as small buildings or breaking them up for the top-grade lumber from which they had been built.

TECHNICAL DATA - CG-4A

Type:	Cargo and troop glider
Accommodation:	15 troops
Span:	83 ft 8 in
Length:	48 ft 4 in
Height:	12 ft 7 in
Wing area:	852 sq ft
Empty weight:	3,700 lb
Gross weight:	7,500 lb
Max speed:	120 mph
Army serial numbers:	42-61101/61460, 42-61821/62210

DOUGLAS ATTACK BOMBERS (DB-7B, Boston, A-20C) - A total of 380 Douglas DB-7B 3-seat attack bombers was built under licence by Boeing, 240 on an order initially placed by the French government but completed for England, and 140 for the US Army. The DB-7 (Douglas Bomber No. 7) was developed in 1938 as an Army attack aircraft, and France was permitted to place orders for export models to be produced simultaneously with the Army models. Following the German occupation

The first 240 Douglas DB-7Bs built in Seattle were for an original French order taken over by Britain. Some Bostons were diverted to Russia and others to the US Army. (*Photo by Gordon S Williams*)

of France in 1940, the French orders were taken over by Britain. Some of the aircraft were diverted to the USSR after it joined the Allies. The first contract for Boeing production was signed on May 18, 1940, and the aircraft were all delivered between October 30, 1941, and March 31, 1942.

TECHNICAL DATA - DB-7B (A-20C)

Designer:	Douglas Aircraft Co
Type:	Attack
Accommodation:	Bombardier, pilot, gunner in tandem
Power plant:	2 Wright R-2600-23, 1,600 hp
Span:	61 ft 4 in
Length:	47 ft 4 in
Height:	17 ft 7 in
Wing area:	464 sq ft
Empty weight:	15,625 lb
Gross weight:	19,750 lb
Max speed:	342 mph at 13,000 ft
Cruising speed:	280 mph at 5,000 ft
Climb:	10,000 ft in 5 min
Service ceiling:	28,600 ft
Range:	1,050 miles
Armament:	2 fixed ·50 cal MG, 3 flexible ·30 cal MG, two 500 lb bombs

• Boston III - DB-7B was the Douglas designation of this aeroplane. Boston was the type name assigned by the Royal Air Force and followed a name identification system that dated back to WW-I. Some of the Boeing-built DB-7s sent to England on direct-purchase contracts were later modified as two-seat night fighters under the designation of Havoc. The first flight of a Boeing-built DB-7 was on July 24, 1941.

C/ns:	2130/2203, 2718/2883
RAF serial numbers:	AL-263/336, AL-337/502

The second order for Boeing-built Douglas DB-7s was placed by the US Army with Lend-Lease funds, which resulted in assignment of the Army designation A-20C. (*Photo by Gordon S Williams*)

• A-20C – The A-20Cs were built under a US Army contract and differed from the earlier Douglas-built A-20As in that they were equipped like the Bostons built to British order. With the advent of Lend-Lease, many US-built military aircraft were purchased with US funds and carried standard US military designations and serial numbers but were fitted with British equipment and delivered to the Royal Air Force and other Allied units in the markings and serial numbers of those countries. The Boeing-built A-20Cs were continuations of the Boston III production but were paid for with US Army funds. Although originally intended for use by the RAF, the majority of the Boeing-built A-20Cs were diverted to US Army use and flew with US military markings applied over the original British camouflage.

C/ns: 2885/3024
Army serial numbers: 41-19589/19728

CANADIAN-MANUFACTURED AIRCRAFT

The aircraft building activities of Boeing Aircraft of Canada were revived in 1937, when a modern plant was built at Sea Island Airport, Vancouver, B.C. The initial product of this factory was the British-designed Blackburn Shark torpedo aircraft. Other aircraft production of the war years was devoted to flying-boats and amphibians designed by Consolidated, to the manfuacture of sub-assemblies for B-29s, and for various Canadian aircraft manufacturers, and to the overhaul of aircraft. No factory serial numbers are known for the wartime aircraft by the Canadian subsidiary. The plant was sold immediately upon the end of the war, but the Canadian subidiary was not formally dissolved until 1953.

A new Boeing of Canada was created in 1960 when Boeing bought the Vertol Aircraft Corp of Morton, Pa., builder of helicopters. A branch Vertol plant at Arnprior, Canada, was part of the acquisition. In 1986, Boeing bought de Havilland of Canada, but the products of that firm are still marketed as de Havillands.

Landplane version of the British-designed Blackburn Shark torpedo-bomber built by the new Boeing-Canada plant at Vancouver, BC, in 1937 as Shark III. (*Photo by Gordon S Williams*)

BLACKBURN SHARK – In 1936, the Royal Canadian Air Force took delivery of the first of seven British-built Blackburn Shark II torpedo aircraft. These were conventional two-to-three seat biplanes that could be fitted with wheels or twin floats. Structure was all metal, with fabric covering, and the power plant was the British Armstrong Siddeley Tiger. After delivery of the British-built models, the RCAF ordered an additional 17 from the new Boeing-Canada plant under the designation of Shark III. The principal difference from the Mark II version was the substitution of a 800/840 hp Bristol Pegasus engine and partial enclosure of the cockpits. All parts of the aircraft, except the stainless steel spars which were supplied by Blackburn, were made in Canada.

TECHNICAL DATA – BLACKBURN SHARK III (Landplane)

Type: Torpedo bomber, land or sea
Accommodation: 1 pilot, 1 navigator/gunner (normal)
Power plant: Bristol Pegasus Mk. 9, 800/840 hp
Span: 46 ft
Length: 35 ft 2¼ in
Height: 12 ft 1 in
Wing area: 489 sq ft
Empty weight: 4,039 lb
Gross weight: 7,870 lb
Max speed: 152 mph at 5,500 ft
Landing speed: 62½ mph
Climb: 820 ft/min at 500 ft
Service ceiling: 16,400 ft
Range: 550 miles

C/ns: 501/517
RCAF serial numbers: 514/524, 545/550

Seaplane version of the Boeing-built Blackburn Shark. (*Peter M Bowers Collection*)

CONSOLIDATED AMPHIBIANS AND FLYING-BOATS

A total of 362 PBY flying-boats and amphibians designed by the Consolidated Aircraft Corporation (later Consolidated-Vultee and ConVair) of San Diego, California, were built under licence for British Empire services and the US Navy. The original British designation for the PBY series was Catalina, which was subsequently adopted by the US Navy and applied to both the flying-boats and the amphibians. The RCAF, however, distinguished the 55 Boeing-built amphibians by naming them Canso A. Of the remaining 307 PBY flying-boats, 75 were direct British purchases and 232 were purchased with Lend-Lease funds under the US Navy designation of PB2B-1 and -2 to indicate that they were the second Patrol Bomber design procured from Boeing regardless of the original designer. A few of the PB2Bs were retained by the US Navy but the majority were delivered to Empire services in RAF colours and were operated as Catalinas. For the Lend-Lease models, both US Navy and RAF serial numbers were carried simultaneously.

• CANSO A (PBY-5A) – Fifty-five PBY-5A amphibians (the letter A in the US designation identified the amphibious version) were built for direct purchase by the RCAF and were delivered between October 1942 and July 1943. No Boeing or US Navy designation was applied.

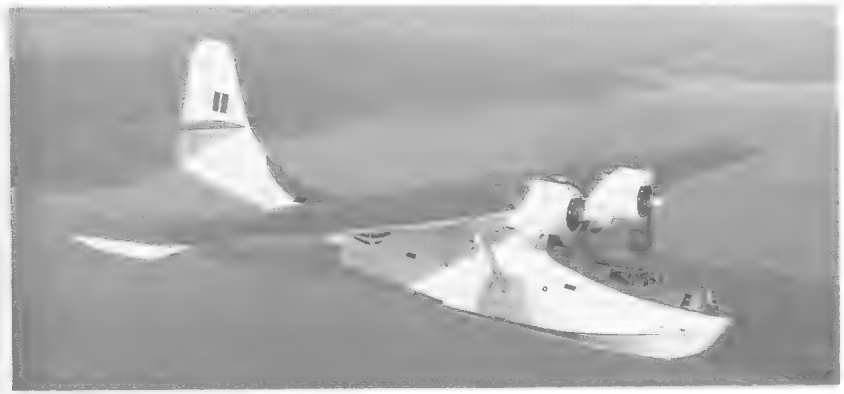
RCAF serial numbers: 9751/9805

• CATALINA IVB (PB2B-1) – The 240 PB2B-1/Catalina IVBs duplicated the standard US Navy PBY-5 flying-boat model as built by Consolidated. Deliveries from July 1943 to October 1944, with 34 sent to New Zealand.

RAF serial numbers	*US Navy serial numbers*	*New Zealand serial numbers*
JX270/344 (75)	none	none
JX345/349 (5)	72992/72996	none
none	72997/73000	NZ4023, 4029, 4024, 4025
JX350/361 (12)	73001/73012	none
none	73013/73016	NZ4026, 4043, 4027, 4030
JX362/373 (12)	73017/73028	none
none	73029/73032	NZ4042, 4028, 4031, 4032

The consolidated PBY-5 flying-boat built by Boeing-Canada under the dual designation of PB2B-1 (US Navy) and Catalina IVB (Royal Air Force) shown on beaching gear. This one, in RAF markings, carries US Navy serial number 73096 and designation PB2B-1 on the tail. It went to New Zealand as NZ4050. (*Crown Copyright*)

JX374/383 (10)	73033/73042	none
none	73043/73048	NZ4033/4038
JX384/389 (6)	73049/73054	none
none	73055/73060	NZ4039, 4046, 4040, 4041, 4044, 4045
JX390/423 (34)	73061/73094	none
none	73095/73098	NZ4047, 4050, 4051, 4048
JX424/437 (14)	73099/73112	none
none	73113/73116	NZ4049, 4054, 4052, 4053
JX586/599 (14)	44188/44201	none
none	44202/44203	NZ4055, 4056
none	44205	none
JX600/613* (14)	44206/44219	none
none	44220/44223	none
JX614/617* (4)	44224/44227	none



Catalina VI JX637 in grey and white RAF Coastal Command colouring. (*Boeing-Canada Photo*)

• CATALINA VI (PB2B-2) – The 67 Catalina VIs, or PB2B-2s, were improved PBY-5 flying-boats that could be distinguished from the earlier Consolidated and Boeing-built Catalinas in having a noticeably taller vertical tail. This had been introduced on the PBN-1, which was an improved PBY-5 built at the US Naval Aircraft Factory. Consolidated built an amphibious version as the PBY-6A. The PB2B-2/Catalina VIs were delivered between September 1944 and March 1945. Several were operated for a while by the Army under their Naval designations and serials.

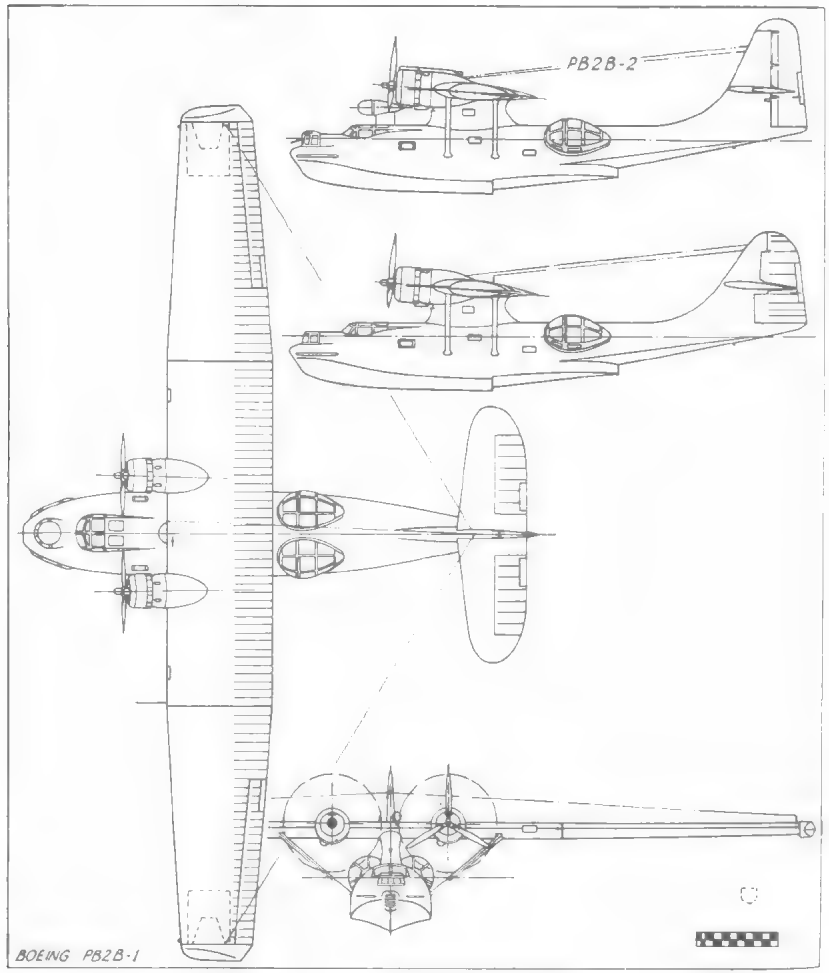
RAF serial numbers†	*US Navy serial numbers*	*RAF serial numbers†*	*US Navy serial numbers*
JX618/627	44228/44237 (10)	JX628/662	44246/44280 (35)
none	44238/44245 (8)	JX828/841	none

* JX611/617 to Australia as A24-206, 201, 204, 205, 203, and 200, respectively
† All but 13 to Australia as A24-301/309, A24-350/386

TECHNICAL DATA - Consolidated PBY-5/Boeing PB2B-1 (Catalina IV)

Type:	Patrol bomber flying-boat	*Wing area:*	1,400 sq ft
Accommodation:	8 crew	*Empty weight:*	18,790 lb
Power plant:	P & W R-1830-92, 1,200 hp at 2,700 rpm for take-off	*Gross weight:*	33,133 lb
		Max speed:	187 mph at 7,000 ft
		Climb:	560 ft/min
Span:	104 ft	*Service ceiling:*	15,800 ft
Length:	65 ft 1 in	*Range:*	2,690 miles at 110 mph
Height:	18 ft 6 in		

Armament: Two ·50 cal MG, three ·30 cal MG, 4,000 lb bombs or mines when operating at less than maximum patrolling range



Chapter 8

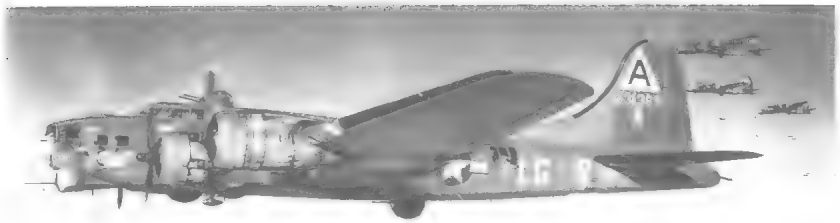
THE B-17 FLYING FORTRESS

In July 1935, Boeing introduced an entirely new bomber, the four-engine Model 299, which had been designed and rushed to completion at company expense for entry in a scheduled Air Corps competition for multi-engine bombers that had been announced in May 1934, with the finished aeroplanes to be flown and evaluated at Wright Field in August 1935. In addition to being a purely speculative effort on the part of the company in that there would be no compensation if the design did not win, the 299 was a daring gamble in the interpretation of the intent of the specification to which it was built. Unless specifically stated otherwise, the term 'multi-engine' was generally considered at the time to mean two engines, and it was known that the other aeroplanes in the competition would be of that type.

Four-engine bombers were not new, having been produced fairly regularly in small quantities ever since the appearance of the Russian Sikorsky in 1914. The backbone of the world's bomber forces, however, was made up of the smaller twin-engine types that were generally matched in size and performance, if not exceeded, by contemporary civil transports. The four-engine types had traditionally been slow, clumsy, and relatively underpowered, and the use of four or more engines was necessary to get these larger load-carrying aeroplanes into the air with the available power plants. Extra engines had not been seriously considered as a means of increasing the performance of a smaller aeroplane with a load capacity held to that of normal twin-engine types, so in this respect the 299 concept was entirely new.

Boeing engineers realized that several conventional twin-engine bomber designs, carrying approximately equal loads and using comparable power plants, would turn in very similar performances. A large performance improvement was needed to produce a winning design, but it had to be obtained with the same power plants available to the competitors and by techniques within the limits of the existing state of the art of aircraft design and construction. Cleaning up of the basic multi-engine airframe had practically reached the maximum with the B-9 of 1931, so there was little to be gained by further refinement of line. About the only way to increase performance by conventional means was to increase the available power by adding engines. Because of equipment, crew position, and defensive armament requirements, a third engine in the nose was unacceptable, making an even number of power plants mandatory.

At the time the bomber competition was announced, Boeing had a larger four-engine bomber, the XBLR-1/XB-15 (Model 294, Chapter 6) under



Flying Fortresses operating in the European theatre adopted the British style of squadron identification letters as shown by this camouflaged B-17G-15-BO. The letters LG identify the 322nd Squadron of the 91st Bomb Group, indicated by the Triangle-A on the fin. The letter R identifies the 18th aeroplane in the 91st group. (*USAF Photo via Boeing*)

development. This, while modern in outline, was designed to the traditional concept of adding engines for the primary purpose of meeting the power requirement of the large aeroplane. After some cautious checking with the Air Corps to ascertain that the official interpretation of the term multi-engine did include four-engine types, the full facilities of the company were concentrated on the development of a smaller four-engine Model 299. Preliminary work began on June 18, 1934, and construction started on August 16.

The resulting bomber can be most accurately described as a direct structural and aerodyamic combination of the Model 247 transport (Chapter 6) and the unfinished XB-15. General construction details were very similar to those of the 247 while the engine arrangement, circular fuselage cross-section, and general distribution of crew and military equipment followed the XB-15 design. Dimensionally, the 299 was approximately half-way between the two, but the wing span of 103 ft 9 in was only 8 ft 3 in greater than that of the twin-engine Douglas DB-1, the most significant competitive design.

After a short period of testing at the factory, the Model 299 was delivered to Wright Field for evaluation, making the 2,000 mile nonstop flight at an average speed of 252 mph. This performance, coupled with the size, weight, and armament of the four-engine design, plus the inspired name of Flying Fortress, resulted in a rash of publicity unlike that given to any individual aeroplane since the transatlantic flight of Lindbergh's *Spirit of St Louis* eight years before.

The full military capability of the 299 could not be demonstrated before it crashed on October 30, 1935, following a take-off made with the controls inadvertently locked. However, the potential of the design was so great that the Air Corps placed a service test order for 13 Model 299 aeroplanes, incorporating only slight changes, under the military designation of B-17.

A new factory, known as Plant 2, was built on the west side of Boeing Field for production of the service test Y1B-17s, Model 307 Stratoliners, and the small production orders for various improved B-17s that followed. Large-scale production did not get under way until shortly before US entry into WW-II, because of limited appropriations and much controversy within the Air Corps as to the practicability of such large and expensive

Standard Manufacturers Aircraft Assocation nameplate for other builders of the B-17. Note two plates for Lockheed-built B-17Fs; Vega was a wholly-owned subidiary of Lockheed. (*Courtesy William T Larkins*)

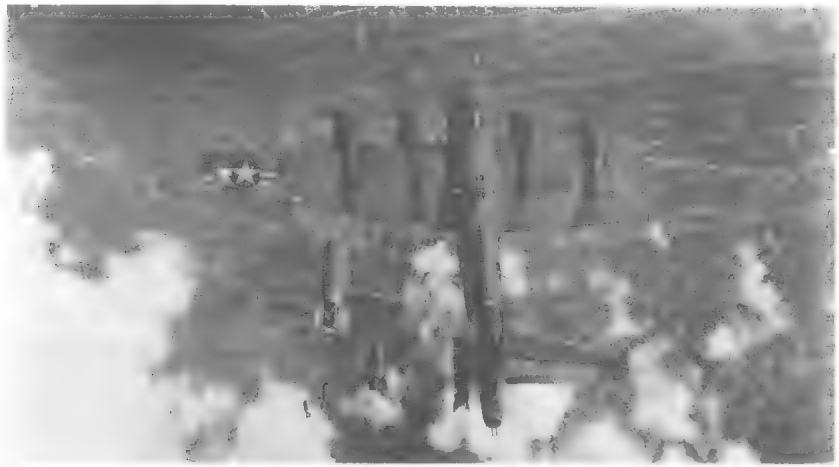
machines. Many argued that the size and complexity exceeded the pilot's capability and urged the procurement of larger numbers of smaller machines with the same money. The fact that a top Army test pilot burned out two engines and the brakes of the first service test model and stood it on its nose supported the 'too complex' argument. However, gathering war clouds brought increasingly large orders. Following development of the greatly improved B-17E model, the Air Corps encouraged the organization of a manufacturing pool whereby Boeing, Vega (a subsidiary of Lockheed Aircraft Corporation), and the Douglas Aircraft Company would all manufacture B-17Es. By the time the pool (irreverently referred to as B.V.D., the initials of a famous brand of underwear that had practically become part of American folklore) was ready for production, a newer B-17F model was ready, so this was the first to be produced jointly in the three plants. Since the Army system of designating aircraft did not specify the manufacturer, a B-17 was a B-17 no matter who built it, and the designation

Interference between the waist gunners in the B-17E was the reason for staggering the gun ports on later models. (*Boeing Photo P-1626*)

The rugged fuselage structure of this B-17F enabled it to return to its base after a mid-air collision with an Me 109 over North Africa. (*Boeing Photo P-33560*)

did not change. Production by different firms, however, caused the Air Corps to add a suffix to the basic designation to identify the actual manufacturer (see page 14). Each manufacturer used its own factory serial numbering system, so only Boeing-built B-17Fs and Gs fit into the sequence of Boeing serial numbers started in 1916. Altogether, 12,726 B-17s of all models were built, 6,981 of them by Boeing, 2,750 by Vega, and 2,995 by Douglas. Boeing production was completed in April 1945.

While the designation of production B-17s ended with the B-17G, there were many experimental variations and outright redesignations of the aeroplane for other purposes. In most cases, the basic bomber designation was retained but modified to specify a different purpose, such as CB-17G for a transport version of the B-17G stripped of all armament and provided with extra seating, TB-17G for a training version, QB-17G for radio-controlled target drone versions, etc. Except for TBs, this was especially prevalent as the aeroplane got older and became available for other than their primary function as bombers. Changes involving basic revision of the B-17G structure to accommodate an airborne lifeboat resulted in a new



Not all bombing missions went according to plan. This B-17F was struck by bombs from the aircraft above it during a daylight raid on Berlin. (*USAF Photo*)

series letter, B-17H, while a change in the primary tactical function of the aeroplane resulted in a redesignation by type, such as C-108 or F-9.

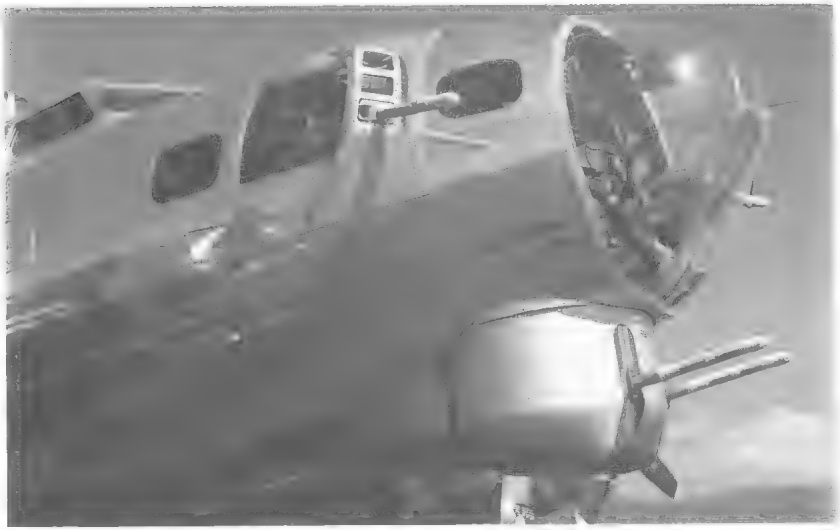
Prefix designations applied to special-purpose B-17s are listed below:

CB-17 Transport conversion
DB-17 Director aircraft for radio-controlled drones
EB-17 Electronics
EB-17 Exempt. Used by Air Force contractors under Bailment Contract (1948–1955)
FB-17 Photographic version, not to be confused with F-9
JB-17 Special test (1955)
QB-17 Radio-controlled drone (usually a target)
RB-17 Restricted; not to be used for primary mission. Symbol assigned to B-17s through to D on October 22, 1942, because of obsolescence. Not to be confused with R-for-Reconnaissance prefix of 1948
RB-17 Reconnaissance. F-9 and FB-17 (photographic) aircraft redesignated in 1948
SB-17 Search and Rescue conversion, sometimes with lifeboat (Ex-B-17H)
TB-17 Trainer
VB-17 Staff transport similar to CB-17

Despite dissension within the Air Corps as to their desirability, the early B-17s got widespread publicity all out of proportion to their actual numbers through several long-distance goodwill flights to Central and South America. A few made international headlines when used to intercept ocean liners far at sea on training missions for their coastal defence role. Protests to the State Department from foreign governments put an early end to this.

The initial combat experience of the B-17 was far from a spectacular success. The 20 B-17Cs delivered to England as Fortress Is were intended to be trainers but were rushed into high-altitude bombing raids against heavily-defended ground targets, a type of mission for which the aeroplane was not originally intended.

Inadequacies in defensive armament, fuel system protection, and operating capability at extreme altitude soon became apparent, and the Fortresses were withdrawn from European operations and sent to other theatres. The experience gained was valuable, however, and remedial features were incorporated in later models. The American-manned B-17s might have made a better showing had they gone into combat with reasonable preparation. Of 33 B-17Cs and Ds stationed in the Philippines at the time of Pearl Harbor, 18 were destroyed on the ground in the first Japanese air raids. Others were caught on the ground at Pearl Harbor, and an additional 12 reconnaissance aircraft, which were being ferried from California to Hawaii without guns because of the extra fuel, spare parts, and supporting equipment that they carried, arrived at the height of the attack. They were considerably shot up before they could scatter, and while none



Heavy forward firepower in the nose of the last combat model of the B-17, the G. Note extended cheek positions to permit a farther-forward firing angle. (*Boeing Photo P-4722*)

were shot down, some were damaged in forced landings on beaches and golf courses. Total B-17 strength in the Western Pacific on March 18, 1942, was 26, all based in Australia. Some were former Philippine-based B-17Cs and Ds which had removed to Java and had been evacuated from there on March 1, carrying as many as 31 evacuee passengers in addition to the operating crews. The wide variety of missions that these B-17s flew, combined with their performance, resulted in an official Japanese comment that the B-17 was a 'a four-engine pursuit plane used for all purposes'.

The only action of WW-II in which the B-17 was used for its original purpose was the Battle of Midway, June 4, 1942. Seventeen were used to locate and attack the Japanese surface fleets supporting the planned invasion of Midway. Even then, combat performance and bombing accuracy were not what they should have been because the aircraft were rushed into action with hastily-installed equipment and green crews that had only two days' previous experience in the type and were exhausted by the long flight to the combat area. While the major damage to Japanese ships was by carrier-based torpedo and dive bombers, the B-17 proved the great superiority of the fast four-engine landplane over the slower flying-boat for long-distance tactical reconnaissance. As a result, the Navy cut down on future flying-boat procurement and completely cancelled the order for 57 Boeing PBB-1 Sea Rangers in favour of landplane patrol types.

European operations opened on a small scale with a daylight sortie by B-17Es against Rouen, on August 17, 1942, which was accomplished without losses. The Es were quickly withdrawn, however, and replaced with Fs. The bombing of targets in occupied Europe by the US and British bomber fleets was soon co-ordinated so that the RAF bombed by night

Times and missions change. Above, B-17Fs are forced to release their loads of twelve 500 lb bombs from maximum altitude in 1943 because of accurate anti-aircraft artillery fire (flak). Below, a TB-17 sprays trees in the city of Lansing, Michigan, from an altitude of 200 ft to protect them from infestation by gipsy moths in 1953. Imagine a B-17 at this altitude over Berlin ten years earlier!
(*Upper Photo USAF 25752-AC*)
(*Lower Photo courtesy Richard L Baxter*)

A B-17G with manned wingtip gun pod, typical of the many experimental and test purposes to which B-17s were put in the years following WW-II. (*Courtesy Alberto Salvati*)

while the AEF bombed by day. In spite of their strong defensive armament, B-17s suffered relatively heavy losses from German fighters when operating beyond the range of fighter cover. The tail armament discouraged attack from the rear, so the Germans developed head-on attack techniques that quickly produced additional forward firepower for the B-17, first in the form of extra hand-held guns on the B-17F and finally a two-gun powered turret on the B-17G. B-17 operations against Germany proper began in January 1943.

The last Boeing-built B-17G was delivered on April 13, 1945. When the war ended in Europe, thousands of B-17s in the European theatre were returned to the United States and declared surplus. A few hundred remained on the active list as VIP transports, trainers, search-and-rescue and research types, drones, and drone controllers. With the increasing development of guided missiles in the mid-1950s, more of the remaining B-17s were converted to radio-controlled targets for the missiles. Counting the short career of the original Model 299 or 'XB-17' in 1935, the B-17 series had a US military life of 25 years. The average cost of the B-17G in service quantities is broken down as follows:

Airframe	$127,069
Engines	38,483
Propellers	11,900
Electronics	9,040
Ordnance	6,342
Miscellaneous equipment	45,495
Total	$238,329

One of the distinctively marked QB-17G drones flown by radio control through the Bikini Atom Bomb cloud in 1946 to test for radioactivity without endangering human life. (*Logan Coombs*)

While a few of the surplus B-17Fs and Gs entered civil aviation or were delivered to various small air forces, the majority were stored temporarily on such southwestern airfields as Kingman, Arizona, right after the war and were eventually scrapped.

MODEL 299 ('XB-17') – Although the Boeing entry in the multi-engine bomber competition of 1935 rolled out of the factory in standard Air Corps markings, it was a company-owned aeroplane and carried the civil registration of X-13372 in the standard positions on the wing and superimposed on the Army rudder stripes. No military designation was applied to this aeroplane, although it has been referred to unofficially as the 'XB-17' ever since the designation B-17 was assigned to the 13 service test models in January 1936. Boeing originally submitted the 299 for the competition as Model X-299, but the Army objected to the designation as being too similar to experimental military project numbers, so it was officially changed to B-299.

Boeing Model 299, named Flying Fortress, was the prototype of the B-17 series. Note the blacked-out side gun blisters to prevent a glimpse into the interior. (*Photo by Gordon S Williams*)

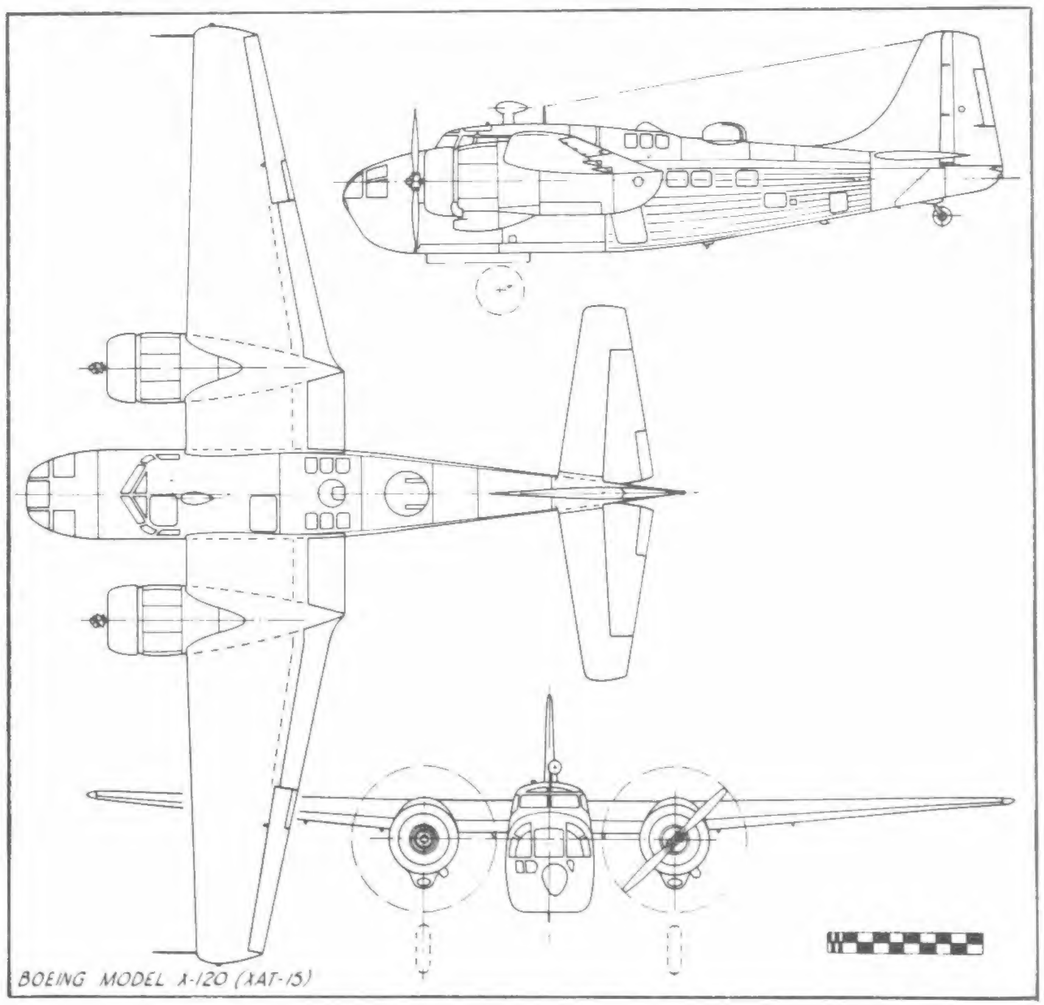
The B-299 (c/n 1963) carried a crew of eight – pilot, co-pilot, bombardier, navigator/radio operator, and four others who served mainly as gunners. There were four defensive machine gun stations in blisters mounted on each side, the top, and the bottom of the fuselage aft of the wing and another gun was carried in a nose turret. All were manually swung and could be either ·30 or ·50 calibre. All bombs were carried internally in a bomb bay between the wing spars that could accommodate up to eight 600 lb bombs.

The B-299 first flew on July 28, 1935, and was ferried to Wright Field on August 20. It crashed on October 30 when the Army test pilot took off with the controls locked. The wreckage was salvaged and a section of the fuselage containing the side gun blisters was used at Wright Field for developing improved gun mounts for later B-17 models.

The B-299 was built at a cost of $432,034. In this day of $100 million aeroplanes (1988), it is difficult to appreciate what a colossal gamble the small (600 employees, down from 1,700) Boeing Airplane Company made in building that revolutionary aeroplane. Its costs almost totally consumed the cash reserve that was left to the newly-independent company after the forced breakup of United Aircraft and Transport in 1934.

The first of two XAT-15 bomber crew trainers (Boeing Model X-120), built to use non-strategic materials at a time of critical aluminium shortage early in WW-II. (*Boeing Photo P-23242*)

MODEL X-120 (XAT-15) – Two XAT-15s, named Crewmaker, were built as Stearman entries in a 1942 bomber-trainer competition, and because of the prevailing aluminium shortage were of composite construction. The fuselage was welded steel tubing, fabric covered, and the tailplane, fin, and wing were of wood with plywood covering. The XAT-15s were complete



'Baby Bombers' intended to give integrated training to an entire light bomber crew consisting of bombardier, pilot, co-pilot, and gunner. Production contracts for 1,045 AT-15s, with 325 to be built by Bellanca and 360 by McDonnell, were cancelled when the Army decided against composite construction for advanced trainers. The funds allocated to the AT-15 programme were transferred to the all-wood Fairchild AT-21, with Bellanca and McDonnell sharing in the production of the twin-engine bomber-trainer.

TECHNICAL DATA - XAT-15

Type:	Bomber-trainer
Accommodation:	Bombardier, pilot, co-pilot, radioman/gunner
Power plant:	P & W R-1340-AN-1 550 hp
Span:	59 ft 8 in
Length:	42 ft 4 in
Height:	13 ft 1 in
Wing area:	457 sq ft
Empty weight:	10,640 lb
Gross weight:	14,355 lb
Max speed:	207 mph at 5,000 ft
Cruising speed:	185 mph
Climb:	10,000 ft in 11·9 min
Service ceiling:	18,900 ft
Range:	850 miles
Armament:	One ·30 cal MG, ten 100 lb bombs
C/ns:	120000, 120001
Army serial numbers:	41-23162, 23163

WACO CG-4A – The Cessna Aircraft Company of Wichita, Kansas, was one of sixteen manufacturers chosen to mass-produce the Waco CG-4A troop carrying glider. However, Cessna sub-contracted its entire order of 750 gliders to the Wichita Division of Boeing, which literally built them in the aisles of the new Plant 2 while it was tooling up for B-29 production. No Boeing model number was assigned to the Waco design nor were Boeing

The new Wichita Plant 2 built a total of 750 Waco CG-4A troop gliders on a sub-contract from the nearby Cessna Aircraft Company. (*Boeing-Wichita Photo BW-4129*)

The Y1B-17A, intended originally as a static test aircraft, was made flyable to test turbo-supercharger installation. Original nacelle top location is shown here. (*Photo by Gordon S Williams*)

on the Y1B-17s could produce only 775 hp at 14,000 ft. Maximum speed increased to 295 mph at 25,000 ft.

C/ns: 1987
Army serial number: 37-369

MODEL 299M (B-17B) – The Model 299M was the first production aeroplane in the B-17 series. Originally, it was Model 299E, but the alterations resulting from changes in the Air Corps specification to which it was built were sufficient to justify the new factory designation.

Outwardly, the B-17B differed from the Y1B-17 only in having a revised rudder of larger area, larger flaps, and a revised nose that eliminated the greenhouse gun turret and belly bomb-aiming window. Major internal changes were relocation of crew members and a change from pneumatic to hydraulic brakes. The first of 39 B-17Bs flew on June 27, 1939, and all were delivered between July 29, 1939, and March 30, 1940.

The revised nose shortened the overall length by 7 in. Take-off power of the R-1820-51 engines was increased to 1,200 hp, giving a maximum speed of 292 mph at 25,000 ft. Empty weight increased to 27,652 lb and gross weight to 37,997 lb with a maximum overload of 46,178 lb permitted. Armament and bomb load were the same as for the Y1B-17.

Although the 39 B-17Bs were built in a single run of Boeing c/ns, the scattered Air Corps serial numbers show the difficulty the Air Corps had to obtain funds; it could only order the wanted B-17Bs a few at a time.

C/ns: 2004/2042
Army serial numbers: 38-211/223, 38-258/270, 38-583, 584, 610, 39-1/10

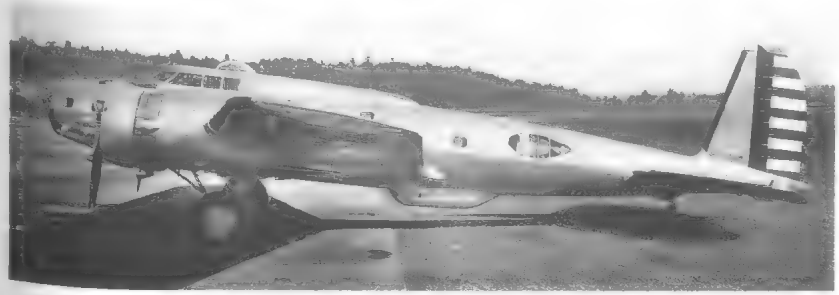
B-17B differed externally from final form of the Y1B-17A by use of enlarged rudder and a redesigned nose. (*Photo by Howard Levy*)

MODEL 299H (B-17C, B-17D) – The B-17C and D were further improved versions of the B-17B and differed from them in minor detail.

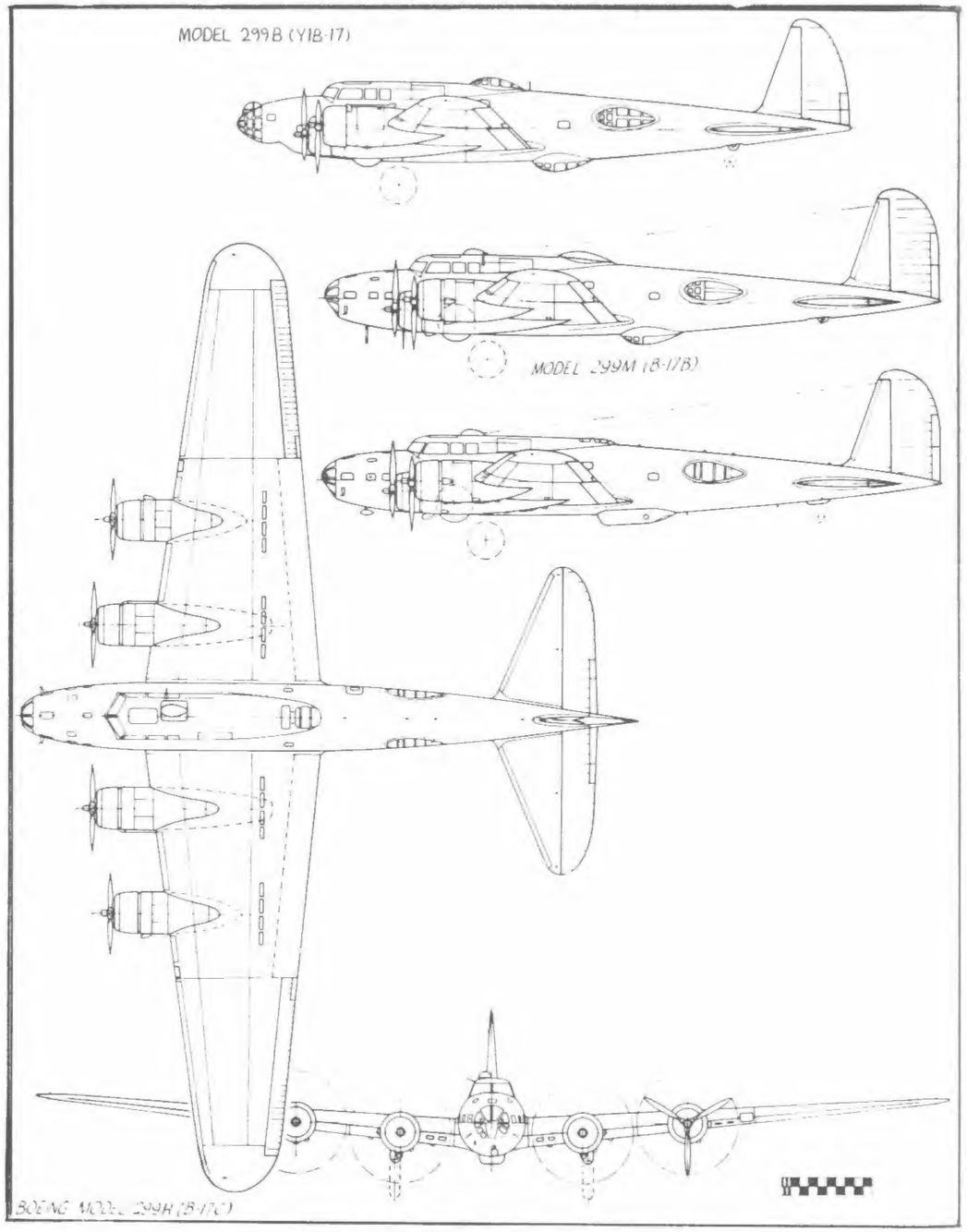
• B-17C – Major outward change in the 38 B-17Cs, all procured on a single contract, was the elimination of the side gun blisters from the fuselage. The bottom blister was replaced by a larger metal 'bathtub' housing. The nose gun mounting was changed from a single socket in the forward window to two sockets in side windows, and dual ·50 calibre guns instead of singles were installed at the top and bottom fuselage positions. Other defensive improvements included addition of self-sealing fuel tanks and armour protection for the crew. The first B-17C flew on July 21, 1940, and delivery was completed by November 29. Twenty B-17Cs were delivered to England as Fortress I (see page 305). B-17Cs remaining in US service were later modified to B-17D standard and redesignated B-17D.

Improved R-1820-65 engines delivered 1,000 hp at 25,000 ft and increased the top speed at that altitude to 323 mph and extended the range, with 4,000 lb of bombs, to 2,400 miles. Empty weight increased to 29,021 lb and gross increased to 47,242 lb.

C/ns: 2043/2080
Army serial numbers: 40-2042/2079



B-17C replaced side gun blisters with flush ports and replaced bottom blister with a 'Tin Bathtub'. Note aircraft commander's sighting blister behind pilots. (*Boeing Photo 12879-B*)



• B-17D – Outwardly, the 42 B-17Ds could be distinguished from the C only by the addition of cowl flaps. Internal changes included electrical system revisions and the addition of another crew member. Both B-17Cs and Ds were delivered from the factory with natural metal finish and standard Army tail stripes. The Army applied olive drab and grey camouflage paint at its own depots starting in March 1941, and practically all B-17Cs and Ds were in warpaint by Pearl Harbor and the US entry into WW-II.

C/ns: 2087/2128
Army serial numbers: 40-3059/3100

B-17D had one additional crew member but differed outwardly from B-17C only in addition of engine cowling flaps. Army began camouflaging first-line aircraft in March 1941. (*Photo by Peter M Bowers*)

MODEL 299-O (B-17E, F, G)– Model 299-O was a major revision to the basic 299. Structural details and layout were generally the same, but the tail surfaces were enlarged and redesigned, the most conspicuous feature being the large dorsal fin. Defensive armament was increased by the addition of a two-gun power turret on top of the fuselage just behind the pilot's cabin, a power turret in the bottom of the fuselage behind the wing and a two-gun manually-operated 'Stinger' turret in the tail cone. The 299-Os were built only as B-17E, F, and G, all later military designations being conversions.

• B-17E – The first of 512 B-17Es was flown on September 5, 1941, with alclad metal surfaces and camouflage on the fabric, but it and all other Es were delivered in full warpaint. The bottom turret installation on the first 112 Es utilized periscope sighting from a Plexiglas bubble located aft of the tuffet, but on the 113th aeroplane this was changed to a Sperry ball turret, in which the small gunner aimed the guns from inside the turret itself. Since B-17Cs and Ds were the first B-17s encountered by the Japanese in the Philippines, they were caught by surprise by the tail turret of the B-17E. Crews of the older models took advantage of subsequent Japanese uncertainty about B-17 firepower and stuck black-painted sticks out of their tail cones. B-17Es were the first bombers to see action with the US forces in Europe.

C/ns: 2204/2480, 2483/2717
Army serial numbers: 41-2393/2669, 41-9011/9245

Prototype B-17E in natural metal finish with remotely-sighted belly turret used on first 112 aircraft. Plexiglas blister for sighting periscope is several feet aft of turret. (*Photo by Gordon S Williams*)

Production B-17E with manned Sperry ball turret flies past Mt Rainier in early 1942 markings – post-Pearl Harbor serial number on tail and red centre in star insignia. (*Boeing Photo P-1197*)

• B-17F – The outward appearance of the B-17F differed from the B-17E only in the substitution of a moulded Plexiglas nose assembly for the built-up assembly used since the B-17B, the addition of wide paddle-blade propellers, and a revision to the engine cowlings to allow the wider propeller blades to be feathered. Interior and equipment changes were more numerous, and included self-sealing oil tanks, additional electrical power sources, changes in control settings, and 1,100 gal additional fuel capacity on later models by adding extra cells, called 'Tokyo tanks', to the fuel tanks in the wings. Some later models had a single ·50 calibre gun in a cheek mount on each side of the nose instead of and sometimes in addition to a single gun in the nose window and added a single ·50 calibre gun in the radio compartment, firing through the skylight.

Because of the great number of relatively small changes constantly being made to the B-17 model as large-scale production got under way, the B-17F was the first Boeing model to carry the additional block designations

The first 112 B-17Es had the remotely-sighted belly turret shown at the left; note sighting blister toward rear of aeroplane. (*Boeing Photo 18297-B*). From aeroplane 113 on, a manned turret was used that could be entered either from the ground or inside the aeroplane. (*Boeing Photo 20251-B*)

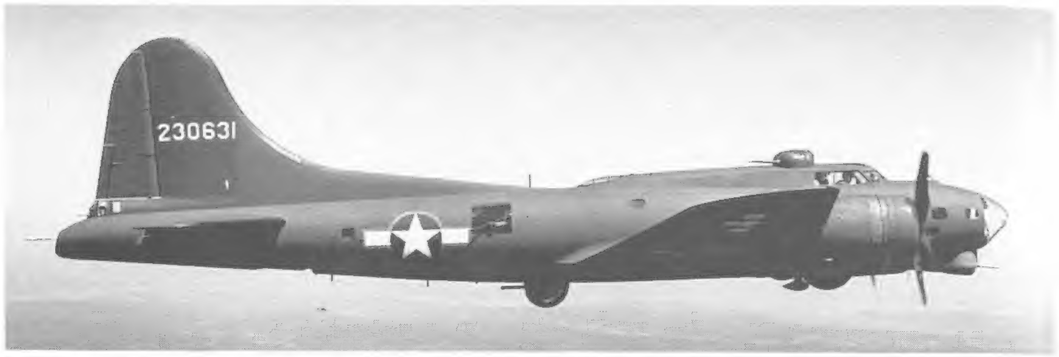
This B-17F has added external bomb racks. Only notable external change from B-17E was longer moulded Plexiglas nose. Red centre of star insignia and letters US ARMY under wings both removed on May 15, 1942. (*Boeing Photo P-3006*)

adopted by the Army. The first 50 were B-17F-1-BO, the second 50 were -5, and the third 50 were -10, with the numbers varying from this point on. Only the first three Douglas-built B-17Fs and the first five Vegas were -1. The details of similar B-17F block numbers as built by the three companies did not correspond, and it was necessary to include the manufacturer's symbol in the designation for complete determination of detail from service publications. Of the 3,405 B-17Fs built, the 2,300 by Boeing reached production block number -130, the 605 by Douglas reached -80, and the 500 by Vega reached -50.

One B-17F, 42-3521, was transferred to the Navy. It received Navy serial number 34106 but was operated under the Army designation. It was later modified to B-17G standard and redesignated PB-1, but then was stripped of all armament and used as a flying aeronautical laboratory. B-17F-BO 41-24613 was turned over to the National Advisory Committee for Aeronautics (NACA) for extensive performance testing as XB-17F.

The major armament changes for the B-17G, consisting of a forward chin turret and relocated side guns, were worked out on B-17F-115-BO 42-30631. Provisions for the chin turret were to be installed in B-17Fs beginning with -135, but the changes were considered sufficient to justify a new series designation and the F-135s became G-1.

The XB-17F was not a prototype, but the 274th Boeing-built aeroplane turned over to NACA for extensive aerodynamic testing. (*NACA Photo AAL-2499*)



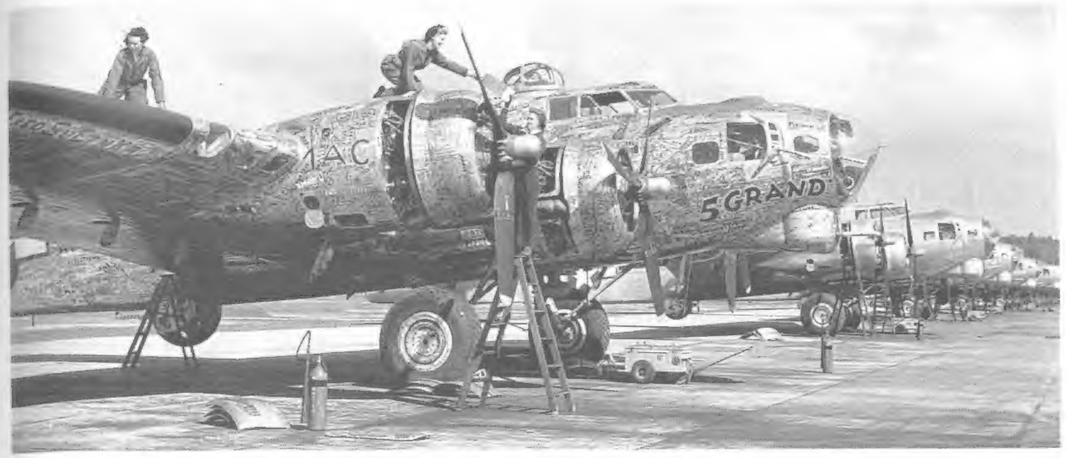
B-17F-115-BO 42-30631 fitted with XB-40 chin turret and revised side gun ports was prototype of later B-17G. White rectangles were added to star insignia in July 1943. Surrounding red border was used only to September and was then replaced by blue. (*Boeing Photo P-3417*)

Dimensions and performance similar to B-17E except for installation of improved R-1820-97 engines. Bomb load increased to 8,000 lb by use of external racks.

	C/ns	*Army serial numbers*
Boeing	3025/3324	41-24340/24639
	3589/4023	42-5050/5484
	4581/6145	42-29467/31031
Douglas	7900/8498	42-2964/3562
	8500/8501	42-33714/33715
	8503/8506	42-33717/37220
Vega	6001/6500	42-5705/6204

• B-17G – The B-17G was the last production version of the B-17 series and was built in the greatest numbers – 4,025 by Boeing, 2,250 by Vega, and 2,395

Production of the B-17 peaked in Seattle in April 1944. These sixteen silver B-17G-65-BOs represent one day's production. (*Boeing Photo P-4744*)



The 5,000th Flying Fortress completed in Seattle following Pearl Harbor, a B-17G-70-BO, was named *Five Grand* to reflect the number and was entirely covered with the signatures of Boeing employees. By special Army permission, the unique markings were retained and carried on 78 combat missions to the end of the war. (*Boeing Photo P-4824*)

by Douglas. Externally, it differed from the late F model only in having the two-gun chin turret developed on the XB-40, staggered waist gun positions that eliminated interference between the gunners on late production versions, and staggering of the side-mounted nose guns so that the left gun was in the forward window and the right gun was in the second window, thereby reversing the positions used on the late Fs. These windows projected beyond the nose contours and remained a fixture on disarmed postwar aircraft. Since the chin turrets were usually removed and the gap covered over, the nose windows became an important recognition feature for distinguishing civilian and disarmed military B-17F and G models in the postwar years.

Minor changes during B-17G production were many. A revised tail gun turret that reduced the overall length by five inches was added on -80-BO, -35-VE, and -45DL models. B-17G-1-VE 42-39840 was redesignated XB-17G by the Army when assigned to test work.

Camouflage paint was deleted from production B-17s starting in January 1944. B-17Gs were delivered in natural metal finish starting in (but not at the beginning of) blocks G-35-BO, G-20-VE and G-35-DL. Depot commanders were given the option of stripping older models on hand for repairs or touching up their existing paint, whichever was considered easiest. As a result, missions to the end of the war were flown with very mixed colouring – unpainted, fresh camouflage, and faded camouflage.

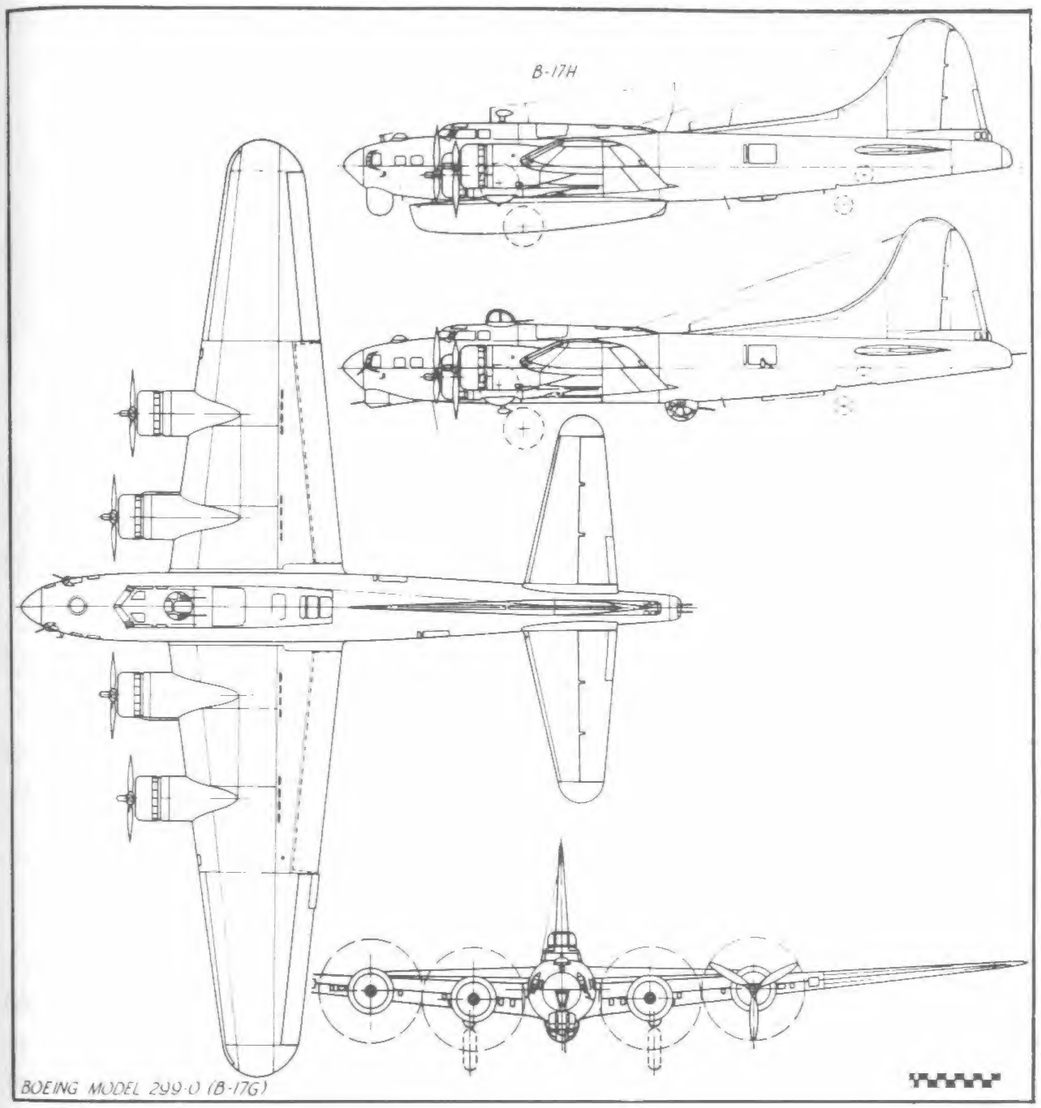
	C/ns	*Army serial numbers*
Boeing	6146/7230	42-31032/32116
	7531/7880	42-97058/97407
	7881/8480	42-102379/102978
	8487/10486	43-37509/39508
Douglas	8419/8499	42-3483/3563
	8500/8999	42-37714/38213
	21899/22148	42-106984/107233
	22224/23223	44-6001/7000
	31877/32526	44-83236/83885

Vega	6501/6800	42-39758/40057
	6801/7400	42-97436/98035
	7401/8400	44-8001/9000
	8401/8750	44-85492/85841

TECHNICAL DATA - MODEL 299-O

	B-17E	*B-17F-1-BO*	*B-17G-80-BO*
Type:	Heavy bomber	Heavy bomber	Heavy bomber
Accommodation:	6–10 crew	10 crew	10 crew
Power plant:	Wright R-1820-65	Wright R-1820-97	Wright R-1820-97
	1,200 hp at	1,200 hp at	1,200 hp at
	25,000 ft	25,000 ft	25,000 ft
Span:	103 ft 9 in	103 ft 9 in	103 ft 9 in
Length:	73 ft 10 in	74 ft 9 in	74 ft 4 in
Height:	19 ft 2 in	19 ft 2 in	19 ft 2 in
Wing area:	1,420 sq ft	1,420 sq ft	1,420 sq ft
Empty weight:	33,279 lb	34,000 lb	36,135 lb
Gross weight:	53,000 lb	56,500 lb	65,500 lb
Max speed:	317 mph	299 mph	287 mph
	at 25,000 ft	at 25,000 ft	at 25,000 ft
Cruising speed:	224 mph	160 mph	150 mph
	at 15,000 ft	at 5,000 ft	at 5,000 ft
Service ceiling:	36,600 ft	37,500 ft	35,600 ft
Climb:	10,000 ft	20,000 ft	20,000 ft
	in 7.1 min	in 25.7 min	in 37 min
Range:	2,000 miles	1,300 miles	2,000 miles
	with 4,000 lb	with 6,000 lb	with 6,000 lb
	bombs	bombs	bombs
Armament:	One ·30 cal,	Ten ·50 cal MG,	11–13 ·50 cal MG,
	eight ·50 cal MG,	6,000 lb bombs	9,600 lb bombs
	4,000 lb bombs		

Late production B-17G-70-BO with chin turret and side nose guns in cheek installations. Compare more rearward location of waist gun port to forward position of right-side gun on B-17G prototype on page 300. Use of camouflage for most US Army combat aircraft was discontinued early in 1944. (*Boeing Photo P-4977*)



MODIFIED B-17s

The B-17G was the last production model of the B-17 series. All higher designations to B-17P were conversions, some in combination with special-purpose prefixes. These all retained the original bomber designation.

• B-17H - In 1945 approximately 130 B-17Gs were to be converted to B-17H and TB-17H search-and-rescue aircraft equipped to carry an airborne lifeboat that could be dropped at sea by means of three parachutes. Only 12 received the B-17H designation, the remainder retaining their G designations. Five became TB-17Hs. The boat was a self-righting self-bailing type equipped with full emergency provisions and was carried under the belly of the B-17H in the former bomb bay location. Some of the earlier conversions, intended for use in combat areas, retained their defensive armament. Others deleted the armament entirely and substituted a search-radar dome for the chin turret. After the Army Corps became the US Air

Peaceful mission for a former bomber. B-17Hs were disarmed B-17Gs fitted with search radar and droppable lifeboats for rescue missions at sea. Black-bordered yellow bands around fuselage and wingtips were tri-service rescue markings. Red bars were added to insignia rectangles in January 1947. (*Photo by Gordon S Williams*)

Force, the old aircraft designating systems were revised and in 1948 the B-17Hs were redesignated as SB-17Gs, the S indicating the primary search-and-rescue mission and the G indicating the basic similarity to the B-17G from the standpoint of structure, engines, and systems.

B-17H serial numbers: 44-83573, 83705, 83710, 83719, 83722, 83794, 83799
TB-17H serial numbers: 44-83700, 83714, 83718, 83791, 83793

During the Korean War of 1950–53 some of the life-boat carrying SB-17Gs operating near the combat zones were refitted with cheek, waist, and tail machine-guns for defensive purposes.

• B-17J – Designation not known.

• B-17K – Designation not known.

• QB-17L – Drone aircraft, as indicated by prefix Q. QB-17Ls were used primarily as targets, and were equipped with television transmitters to provide controlling aircraft and ground stations with a target's-eye view of the attacking missile. Other QB-17s were used for various unmanned but destructive tests, such as the ditching tests conducted by NACA in San Francisco Bay. Ironically, the last QB-17 in operation was destroyed by another Boeing product, the IM-99 Bomarc missile.

• B-17M – Designation not known.

QB-17Ls were obsolete B-17Gs converted to radio-controlled target drones. Red-orange Day-Glo paint with black diagonal stripes increased visibility of the targets. (*Photo by William T Larkins*)

• QB-17N – A drone similar to QB-17L but using different guidance equipment and not fitted with television.

• DB-17P – Surviving B-17Gs converted to director aircraft for the QB-17s. As the need for them diminished, some of the DBs were themselves changed to QBs to meet the same fate that they had sent their sister ships to meet. A few of the DB-17Ps remaining on the Air Force inventory in 1960 found permanent homes, notably at the Air Force Museum, Dayton, Ohio, and the Planes of Fame Museum, Chino, California.

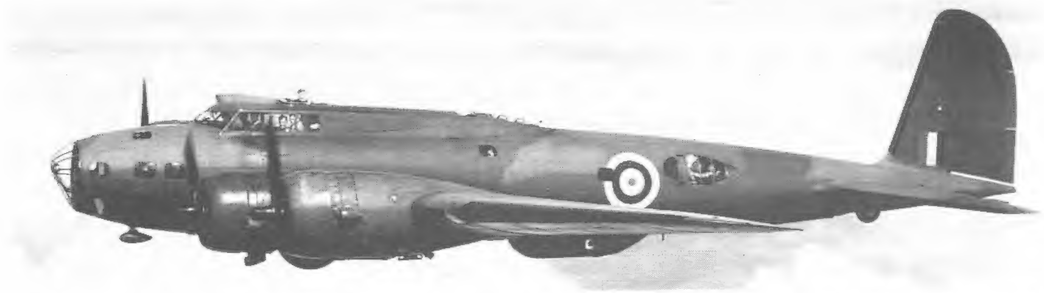
REDESIGNATED AND SPECIAL PURPOSE B-17s

Many B-17 aircraft were so extensively modified or assigned to such different missions that a change of designation was justified. Others were merely redesignated as a result of transfer to the US Navy or to the Royal Air Force. Both military and postwar civil changes are described in the following paragraphs.

• FORTRESS I – Twenty of the 38 B-17Cs were released from the Army Air Corps and delivered to the Royal Air Force under the designation Fortress I. The Boeing model designation was changed to 299U, but there was little change other than the addition of RAF serial numbers. These were initially applied with incorrect series letters, AM instead of the assigned AN. Although intended primarily as trainers, the Fortresses were soon put into action over German-occupied Europe, the first mission being a high-altitude strike against the German Naval base at Wilhelmshaven on July 8, 1941. The combat performance of the Fortress I was disappointing because it had not been designed to operate under the conditions presented by the European war zone.

RAF serial no.	*C/ns*	*Former US Army serial no.*
AN-518	2044	40-2043
519	2045	2044
520	2052	2051
521	2053	2052
522	2054	2053
523	2056	2055
524	2057	2056
525	2058	2057
526	2061	2060
527	2062	2061
528	2065	2064
529	2066	2065
530	2067	2066
531	2069	2068
532	2070	2069
533	2072	2071
534	2074	2073
535	2076	2075
536	2077	2076
537	2080	2079

DB-17Ps were other obsolete B-17Gs used as director aircraft for the QB-17Ls and Ns. The few surviving DB-17Ps were dropped from Air Force inventory in 1960. (*Photo by William E Balogh*)



Twenty of the thirty-eight B-17Cs built were released to the Royal Air Force in 1941 and were named Fortress I because Britain did not use numerical aircraft designation systems. (*Crown Copyright courtesy William Green*)

RAF Fortress IIAs were former Air Corps B-17Es. This one, in Coastal Command markings, was fitted with an experimental nose cannon for use against surface targets.

XB-38 was a Boeing-built B-17E modified by Lockheed for experimental installation of liquid-cooled Allison engines in place of air-cooled radials. (*Boeing Photo 130737*)

XB-40 was the second Boeing-built B-17F converted by Vega to prototype of a heavily-armed escort bomber intended to protect regular bombers when beyond escort fighter range. (*Lockheed Photo B-2192*)

• FORTRESS II – Nineteen Boeing-built B-17Fs were transferred to the RAF under Lend-Lease as Fortress IIs and were assigned RAF serial numbers FA-695 to FA-713.

• FORTRESS IIA – Forty-five B-17Es were turned over to the RAF as Fortress IIA (FK 184/213, FG 449/460, 462/464) because the transfer was made after a batch of later-model B-17Fs had been designated as Fortress IIs by the RAF.

• FORTRESS III – Eighty-five B-17Gs were transferred to the RAF. The first 30 were Boeing-built and the remainder were Vega. RAF serial numbers were HB 761/790 for the Boeings, HB 791/793, 795, 796, 799/803, 805, 815/820, KH 998, 999 and KJ 100/127, KL 830/837 for the Vegas.

• XB-38 – The XB-38 was originally B-17E 41-2401, which had been turned over to Vega for study during the formation of the Boeing-Vega-Douglas manufacturing pool. At Air Corps request, Vega initiated a study to improve the basic bomber by changing from 1,000 hp air-cooled Wright R-1820-97 radial engines to 1,425 hp liquid-cooled Allison V-1710-89 V-12 engines. Negotiations for development of the new design, known as Vega Model V-134-1, began on March 4, 1942, and a contract signed on July 10.

The basic airframe was unchanged except for necessary revisions to accommodate the new engines. The oil coolers of the B-17E were in the leading edges of the wings but were moved to positions under the propellers on the XB-38, and the coolant radiators for the Allison engines were mounted in the leading edge of the wing between each pair of nacelles. The XB-38 first flew on May 19, 1943. Full comparison with the radial-engined B-17 series could not be made because the XB-38 was lost on June 16 as a result of an engine fire that could not be extinguished. Work on two additional XB-38s was cancelled.

• XB-40 – The XB-40 was a Boeing-built B-17F (41-24341) converted by Vega to an experimental bomber escort. The purpose of the design was to provide additional firepower for the defence of bomber formations in areas beyond the range of contemporary single-engine fighters.

Like the XB-40, the service test YB-40s had 'chin' turret under nose, additional top turret, and doubled side armament. Weight of extra armament and ammunition was an operational handicap. (*Lockheed Photo*)

Because of its defensive nature, the XB-40 was a true flying fortress. Fourteen power-driven machine guns were mounted, with an extra turret in the radio compartment position and twin-gun installations at the waist stations instead of singles, plus a two-gun chin turret and the regular top, belly, and tail turrets. The normal ammunition load was 11,135 rounds, which could be increased to 17,265 rounds if the fuel load was reduced.

• YB-40 – Twenty Vega-built B-17Fs (42-5732/5744, 5871, 5920, 5921, 5923/5925 and 5927) were converted to YB-40s to test the escort bomber concept in combat, and four others (42-5833, 5834, 5872, and 5926) were converted to TB-40s for training purposes. Development of this model, known at Vega as V-139-3 but actually modified by Douglas at Tulsa from Vega-built airframes, was not carried beyond the service test stage because of a tactical disadvantage inherent in the design. The heavily armed and armoured B-40 could not keep up with the regular B-17s after they had dropped their bombs on the target and were flying light on the return trip.

One YB-40 was used in a very unusual way. The Germans had a number of flyable B-17s available. While most were used to train fighter pilots in anti-B-17 tactics, some were used for sneak penetrations of Allied territory. At least one made a practice of following homeward-bound B-17 formations, pretending to be a crippled straggler and drawing a B-17 out of the formation to cover it from fighter attack. Once the protective B-17 had pulled in close, the decoy either blasted it with its own guns or called German fighters in by radio to do the job. After being caught by this trick several times, Yankee ingenuity set a counter-trap. The next time the decoy appeared it was not a standard B-17 but a YB-40 that left the formation. Once the decoy had been positively identified as 'not one of ours', a broadside from the YB-40 brought that particular German stratagem to an end.

• BQ-7 – Approximately 25 war-weary B-17s, mostly Fs, were converted to radio-controlled flying bombs under the designation of BQ-7. The conversions were made by US bases in England in 1944 for use against

XC-108 was a B-17E converted to a personal flying office for General Douglas MacArthur. Note early use of drop-down entry door with self-contained steps. (*Boeing Photo*)

heavily defended German positions and the deep fortifications and submarine pens that could not be destroyed by normal bombing. The aeroplanes were stripped of normal military equipment and loaded with up to 9 tons of high explosive and 1,000 gallons of fuel, sufficient for a range of 350 miles at a gross weight of 63,000 lb (maximum gross for the standard B-17F was 48,720 lb). Normal technique called for a two-man crew to make the take-off and get the BQ-7 on course, after which they turned it over to radio control by an accompanying B-17 and left the aircraft by parachute while still over England. The controlling B-17 then convoyed the BQ-7 to the target area and locked its controls on a crash course into the target before turning to escape. Fifteen BQ-7s were despatched against German targets between August 4, 1944, and January 1, 1945, but with little effect.

• XC-108 – One B-17E (41-2593) was converted to a special personal transport for General Douglas MacArthur in 1943. All armour and armament except the nose and tail guns were deleted. Extra windows were installed and the interior was arranged with office space and living and cooking facilities.

• YC-108 – The YC-108 was B-17F-40-VE 42-6036 converted to a VIP transport similar to the XC-108. Many other B-17s were later converted to this basic configuration but designated CB-17 to indicate their status as converted bombers rather than C-for-cargo (transport) designs.

• XC-108A – The XC-108A was B-17E 41-2595 converted to an experimental cargo design to test the feasibility of converting obsolescent

XC-108A was a B-17E fitted with a cargo door for evaluation at a time when obsolescent bombers were considered for possible use in supplementing scarce long-range transports. (*Peter M Bowers collection*)

F-9C was a photo-reconnaissance conversion of B-17G. Note nose modification for tri-metragon cameras. Designation changed to RB-17G in 1948. (*Courtesy Alberto Salvati*)

bombers to heavy cargo types. All armament and military equipment were deleted and a large cargo door was cut in the port side of the fuselage.

• XC-108B – When heavy transport aircraft were in short supply to ferry fuel over the Hump from Burma to China in 1943, experiments were conducted to determine the feasibility of converting bombers to tankers. Boeing-built B-17F 42-30190 was converted to a tanker as XC-108B by deletion of all armour and armament and the installation of extra tanks in the fuselage.

• F-9 – Sixteen B-17Fs (42-3324, 5753, 29676, 29719, 29753, 29783, 29801, 29805, 30083, 30220, 30232, 30252, 30253, 30256, 30268, and 30299) were converted to long-range photo-reconnaissance aircraft under the designation F-9. Bombing equipment was deleted but some defensive armament was retained. Tri-metragon cameras were installed in the nose and other cameras were installed in the bomb bay and aft fuselage.

• F-9A – The designation of F-9A was assigned to an unspecified number of additional B-17Fs converted to photographic configuration similar to the F-9 but differing slightly in camera details. All were later redesignated F-9B after further camera changes.

• F-9B – A total of twenty-five F-9Bs (42-2984, 6129, 6134, 6135, 6138, 6140, 6159, 6164, 6183–6187, 6200, 6201, 29873, 29899, 29902, 29904, 29911, 29913, 29917, 29922, 30469, and 30486) were obtained by redesignating the F-9As and converting additional B-17Fs.

• F-9C – Ten B-17Gs (43-37689, 37711, 37914, 38155, 38162, 38168, 39649, 38651, 38653, and 44-83626) were converted to photo-reconnaissance aircraft similar to the F-9, 9A, and 9B conversion of the B-17F. In 1948, the remaining F-9Cs were redesignated RB-17G, the R indicating the basic reconnaissance mission of the aeroplane.

• PB-1 – A total of forty-eight B-17s were transferred to the Navy during the war and soon after V-E Day. The first two were a B-17F and a B-17G, operated as such until the Naval designation of PB-1 (duplicating the experimental flying-boat of 1925) was assigned on July 31, 1945.

PB-1G was postwar US Coast Guard adaptation of the B-17G for air-sea rescue work and aerial mapping. No. 77254 shown was last B-17 model in US service other than target drones and directors. Photographed on its last mission, October 1959. (*Photo by Peter M Bowers*)

• PB-1G – Seventeen B-17Gs were used by the US Coast Guard, which is part of the Navy in wartime, under the designation of PB-1G. Most were assigned to air-sea rescue work similar to that performed by the Army B-17Hs, often with lifeboats attached, while others were used for aerial mapping. All PB-1Gs carried the yellow and black air-rescue markings, and in their last years carried the national marking on the vertical fin instead of on the fuselage. The last mission flown by a PB-1G was completed on October 14, 1959, thereby outlasting all Air Force B-17s but the target drones and their controllers. The PB-1Gs retained their wartime Navy serial numbers when the Coast Guard went back under Treasury Department jurisdiction in 1946.

Navy serial numbers	*Former Army serial numbers*
77245	44-83885
77246	44-85812
77247/77257	44-85821/85831
85832	44-85832
82855	44-85837
82856	44-85834
82857	44-85838

• PB-1W – Thirty-one B-17Gs, including one B-17F modified to G standard, were used by the Navy as PB-1W, the suffix indicating anti-submarine warfare and similar missions, for which a large radome was built under the bomb bay. One was transferred to the Cornell Aeronautical Laboratory as a jet engine test bed under the designation of XPB-1. Standard colouring for the PB-1Ws was the overall dark blue (almost black) adopted by the Navy in late 1944.

PB-1W was US Navy conversion of B-17G with anti-submarine search radar in a large belly radome. Defensive armament deleted. Colour was very dark blue. (*Photo by Gordon S Williams*)

Navy serial numbers	*Former Army serial numbers*
34106	42-3521 (B-17F-75-DL)
34114	44-83538 (B-17G-85-DL)
77137/77138	Unknown B-17G
77225	44-83855 (B-17G-97-DL)
77226/77228	44-83857/83859 (B-17G-97-DL)
77229/77232	44-83861/83864
77233/77234	44-83868, 83869
77235/77242	44-83872/83879
77243	44-83883
77244	44-83884
77258	44-85683 (B-17G-100-VE)
83992/83998	Unknown B-17Gs

MODEL 299-Z – In 1946, two B-17Gs were drastically modified as flying test beds for new turboprop engines, so a revised Boeing model number of 299-Z was assigned to these airframes. The military features were removed, the pilot's compartment was moved aft, and the nose was modified to accommodate the 5,500 hp Wright XT-35 Typhoon and the Pratt & Whitney XT-34 propeller-turbines. Each test engine was more powerful than all four standard engines operating together.

The first conversion was made for the Army at the Wichita Plant on B-17G-VE (44-85813), and the Army then turned it over to the Wright

Model 299Z, converted from B-17G at Boeing factory, ready to ferry to Pratt & Whitney with dummy nose prior to installation of experimental propeller-turbine. (*Photo by Gordon S Williams*)

Second Model 299Z, converted for Army test of Wright Typhoon propeller-turbine under designation of EB-17G, later JB-17G. Note far-aft location of pilot's cabin. (*USAF Photo*)

Model 299Z/JB-17G was sold by Air Force to Wright Aeronautical Corp, which ccontinued to use it as a five-engine test bed. Shown here with R-3350 reciprocating engine in nose. (*E M Sommerich Collection*)

Aeronautical Company on a bailment contract as EB-17G. This was changed to JB-17G in October 1956. The second was a surplus B-17G-VE (44-85734) obtained by Pratt & Whitney and was converted at Seattle after being assigned the civil registration of NX-5111N. This aeroplane was ferried to Hartford, Conn., with a dummy nose and the XT-34 propeller-turbine was installed there.

MODEL 299AB – After reaching 299Z in design studies for the 299 series, Boeing started through the alphabet again in designating later versions. The 299AB was a special executive transport conversion for TWA, now known as Trans World Airlines, and followed the general details of the wartime XC-108 and the CB-17s. In 1946, TWA bought a low-time B-17G-VE, 44-85728, from a government surplus park and ferried it to Boeing's Seattle plant for conversion. The first civil registration applied to the Model 299AB was NX-4600, but this was soon changed to NL-1B, the L being a new symbol adopted soon after the end of the war to designate former military aircraft issued limited licences because they could not qualify for the standard licences of purely commercial types. The limited type certificate number of LTC-1 was applied to this and other passenger-carrying B-17F and G conversions. TWA used the 299AB primarily for survey and liaison work in laying out its postwar routes in the Near East. At the end of 1947, TWA made a gift of the machine to the Shah of Iran, and the registration became EP-HIM, for His Imperial Majesty.

Model 299AB was a surplus B-17G converted by Boeing to an executive transport for TWA. Note addition of cabin windows. (*Photo by Peter M Bowers*)

Early B-17E captured in the Philippines and flown to Japan in company with two B-17Ds for technical study and development of fighter attack techniques. (*Courtesy Hideya Ando*)

B-17s USED BY THE AXIS POWERS

While overwhelming Japanese air power destroyed the majority of US and British air power on the ground in the Southwest Pacific theatre soon after Pearl Harbor, the rapid advance of Japanese ground forces forced evacuation of Allied bases before all of those aircraft which could not be flown out were destroyed to prevent their capture. As a result, the Japanese acquired many different types of Allied aircraft that could be put back into the air with little effort. At least three B-17s, two B-17Ds and one of the early B-17Es, were flown to Japan, where they were displayed to the public in an exhibition of other captured Allied aircraft. The principal value of these B-17s to the Japanese was the opportunity that they offered for careful evaluation of their capabilities and the development of fighter tactics against them.

The high density of B-17 operations over Europe made it inevitable that a number of relatively intact machines would be forced to land in enemy territory. The Germans were able to put about forty of them back in the air during the course of the war. While most were given high-visibility markings and used in the training of fighter pilots, many were flown in their original colouring with US markings for such clandestine missions as dropping agents behind Allied lines or for brazen daylight reconnaissance. A Luftwaffe B-17 encounter with a YB-40 is described on page 308.

Boeing-built B-17F captured by the Germans, one of approximately forty flyable F-17s available to the Luftwaffe for test, training, and espionage work. (*Courtesy Carson Seeley*)

Swedish conversion of an interned B-17G used as a long-range transport. Note extended nose and airliner-type windows in central fuselage section. (*Courtesy Charles W Cain*)

SWEDISH TRANSPORTS

During the war seven B-17Fs and Gs were converted to scheduled airliners under unusual circumstances. Sixty-eight had been forced to land in neutral Sweden when unable to return to England after raids on Germany, and were interned. Because of the transport aircraft shortage, Sweden undertook extensive conversion of the most airworthy and installed airline-type seats in the stripped interiors. Other than windows, the most noticeable exterior change was the elongation of the nose to increase the passenger capacity. These were used for several postwar years before being replaced by more conventional transports.

Swedish registrations	*Ex-USAF serial numbers*
SE-BAH	42-3543
SE-BAK	42-30661
SE-BAM	42-31163
SE-BAN	42-3490
SE-BAO	42-97115
SE-BAP	42-32076
SE-BAR	42-107067

POSTWAR US CIVIL OPERATIONS

Because of the essentially military nature of its design, the B-17 was eligible only for a limited commercial licence under Limited Type Certificate No.1, issued December 2, 1946. It could not be used to carry revenue passengers even it if could have been converted to an economical and efficient transport. Even so, a few were used as business and executive transports on the CB-17/XC-108 pattern. The large load-carrying capability of the B-17 when fitted with extra tanks made it very suitable for largescale spraying operations and for extended high-altitude mapping. A few even had cargo doors of the XC-108A type installed.

The unique career opened up in 1960 when the first of twenty-three B-17Fs and Gs was converted to a water bomber for the purpose of dumping a water-borate mixture on forest fires. The bomb bay was converted to a 2,000 US gal tank. This was divided into four compartments, each with a separate quick-opening bottom that allowed the water to be salvoed all at once or in sequence. These B-17s, called Air Tankers, operated

A B-17G tanker, N3678G, dropping a water-borate mixture of fire retardant on a forest fire. (*Courtesy Milo Peltzer*)

under contract to the US Forest Service and a few were still used for that work as late as 1984.

Altogether, there were 105 B-17s on the US civil register. These were not procured all at once from immediate postwar stocks; some were acquired over a period from the US Air Force and Navy until the last military model was retired in 1960.

The working civil B-17 fleet was largely grounded by the early 1980s because of the spares problem, particularly Wright R-1820 engines. One

The owner of B-17G Air Tanker N134ON solved the Wright Cyclone engine shortage problem by substituting Rolls-Royce Dart propeller-turbines from a surplus Vickers Viscount airliner. (*Photo by Frederick A Johnsen*)

When the 299Z/JB-17G shown on page 313 became available without its nose, the new owner simply installed the hemispherical cap shown and put the aeroplane to work as an Air Tanker. The photograph was taken at Black Hill Airport, Spearfish, Montana, in June 1967. (*Photo by Norman E Taylor*)

enterprising water-bomber operator installed Rolls-Royce Dart propeller-turbines in place of the original Wright radials to produce a very effective tanker. In 1987 there were only nine flyable B-17s remaining in the United States, all of them serving in a unique new career. They were mostly the property of non-profit and tax-exempt 'Flying Museums' and were restored to their full Second World War configuration and markings for flying demonstrations at air shows and other suitable occasions. Operation and maintenance are done on an unpaid basis by volunteer members of the owning organizations.

In 1988 only 43 complete B-17s are known to be surviving world-wide. Twenty are flyable or can be made so, another 20 are on display in various civil and military museums, and three are abandoned hulks that can be retrieved and restored at least to display condition.

Chapter 9

THE B-29

If for no other reason than the part it played in bringing an early end to the Pacific phase of WW-II, the B-29 Superfortress must be recognized as one of the outstanding aeroplanes in the history of military aviation. Aside from its tactical performance, the B-29 deserves recognition for the contribution that it made toward subsequent design and for the truly heroic development programme that in four years designed, built, tested, and perfected one of the most complex pieces of movable machinery ever made up to the time and trained the crews that put it in action over ranges never before attained in combat operations.

The B-29 was not the result of a single design development built around a published specification as had been the custom with most military aircraft. It started this way in March 1938, as Model 334, a design study requested by the Army Air Corps for a pressurized version of the B-17 with tricycle undercarriage. World War II had not started and the Army was hard-pressed to obtain funds with which to procure the existing B-17 model, so development of the new pressurized model could not be pushed very hard officially and Boeing therefore went ahead on its own. Further studies resulted in Model 334A in July 1939, which can be considered the first direct ancestor of the B-29. Still without Air Corps funds, Boeing built a mockup at its own expense in December 1939. In January 1940, the Army issued further requirements for what was becoming known as the

Air Corps Fairchild PT-19A trainer fitted with reduced-scale B-29 wing and tail surfaces as a flying test laboratory for aerodynamic evaluation. (*Boeing Photo*)

B-29 upper forward turret (left). Four guns used from B-29-40 and on, B-29A-20 and on. (Right) View from behind pilots through bombardier's station. (*Boeing-Wichita Photos BW-29382 and BW-24486*)

'Superbomber' type – a bomber with a speed of 400 mph, a range of 5,333 miles, and the ability to deliver a bomb load of 2,000 lb at the half-way point. The original specifications were almost immediately revised to incorporate early WW-II European experience in matters of defensive armament, armour, and fuel tank sealing. The final result was Boeing Model 345, which was submitted to the Army on May 11, 1940. This design was of sufficient interest to win an appropriation of $85,652 for further study and wind-tunnel tests on June 17, and additional funds were obtained on June 27. On August 24, the sum of $3,615,095.00 was appropriated for the construction of two prototype aeroplanes and a static test model, with the Army designation of XB-29. This contract, dated September 6, was amended on December 14 to add a third flyable prototype.

Another mockup was started in May 1941, and in the same month a letter from the Army announced that an order would be placed for 250 aeroplanes to be built in new government-owned facilities at the Boeing Wichita plant. The contract was signed in September and was increased to 500 aeroplanes in January 1942, after the United States had entered WW-II. In February, the Army specified that additional manufacturers would also produce the B-29 in new factories; Bell at Marietta, Georgia, North American at Kansas City, and the Fisher Body Division of General Motors at Cleveland, Ohio. This ordering of an industry-wide programme on a 'paper' aeroplane was unprecedented in aviation history, and was approached only by the Army order for 201 twin-engine Martin B-26s right off the drawing board in 1939.

In addition to incorporating many 'firsts' such as pressurization and remote-control power turrets, the B-29 was the world's heaviest production aeroplane as a result of the increases in range, bomb load, and defensive requirements made by the Army, which produced a wing loading far in excess of previous aeronautical experience. Air Corps technicans were so concerned with the wing loading problem that considerable pressure was put on Boeing to increase the wing area and lighten the loading. Boeing was able to put forth convincing arguments to show how this would reduce overall aeroplane performance by increasing structure, size, and drag, and

was allowed to retain the original dimensions. Much of the high wing loading problem as applied to the critical take-off and landing phases of operation was reduced by the use of Fowler-type flaps, which not only increased the lift coefficient of the wing in the manner of a normal flap but actually added 20 per cent to the overall wing area when extended. In addition to an unprecedented amount of wind tunnel testing, the B-29 wing and tail were tested in flight by substituting quarter-size mockups for the regular surfaces of a Fairchild PT-19A trainer.

While manned turrets as introduced on the B-17E were considered, they were rejected as unsuitable for the operating altitudes of the B-29, and a remote-control system, with the gunners operating the turrets from five sighting stations in the pressurized areas of the aeroplane, was used. Four turrets, two on top of the fuselage and two underneath, each with two ·50 calibre machine-guns, could be controlled from a primary or secondary station, and a fifth turret in the tail was under the direct control of a tail gunner. Normal tail armament was two ·50 calibre machine-guns and one 20 mm cannon.

Full pressurization of the fuselage in the manner of the Model 307 Stratoliner was considered impractical in a bomber, so only the crew areas were pressurized. The nose and mid-fuselage sections were connected by a tunnel through the bomb bays that allowed crew members to change positions during pressurized flight and the tail gunner had a separate pressurized compartment which he could enter and leave only during the unpressurized flight.

Bombs were carried in two bomb bays instead of the traditional one, and the release of bombs was controlled through an intervalometer to preserve aircraft balance by alternating release between the bays. By the end of WW-II, some B-29s had the two bomb bays modified to a single unit to carry a single 22-ton bomb and others were modified to carry a single Block Buster under each wing between the inboard nacelles and the fuselage. In postwar years, bomb bays were further modified to carry research aircraft for air launching.

Side gunner uses B-29 computing gunsight mounted in side blister (left). Tail gunner (right) had separate station under the rudder. (*Boeing-Wichita Photos BW-24478 and BW-24594*)

B-29A centre sections under construction in the Boeing-Renton plant; final assembly lines in the area beyond. (*Boeing Photo*)

Experimental armament on a B-29-25-BW. Two Emerson remotely-controlled power turrets on the nose, two Sperry ball turrets similar to those on the B-17 under the fuselage, two Martin B-26 type turrets on top of the fuselage, and two manually-operated machine-guns in the waist position as on the late B-17Gs. (*Boeing Photos 83587-B and 83589-B*)

The power plant chosen for the B-29 was the completely new 2,200 hp Wright R-3350 twin-row radial. To get the utmost power at altitude, this engine was fitted with two turbo-superchargers instead of the usual one, and the propeller efficiency was preserved by gearing the propeller shaft to 35 revolutions for each 100 revolutions of the engine crankshaft. Oil coolers and the supercharger inter-cooler were mounted directly below the engine cooling air intake, although they were moved slightly aft by the later change that did not get into full production before the postwar cancellations.

Construction was thoroughly conventional – all-metal with fabric-covered control surfaces as standardized by Boeing and the aircraft industry over the previous decade. Each undercarriage unit was fitted with dual instead of single wheels, and a retractable tail bumper was fitted for tail protection during nose-high take-offs and landings. The crew varied in number from ten to fourteen, but normally consisted of two pilots, navigator, bombardier, flight engineer, radio operator, and four gunners.

The prototypes were rushed to completion at Plant 1 and were trucked to Boeing Field for assembly, where the first flight was made on September 21, 1942. The first XB-29 remained at Boeing throughout the war as a test aeroplane. The second was lost on February 18, 1943, while attempting to land at Boeing Field with an inextinguishable engine fire, and the third, incorporating extensive power plant and equipment revision as the result of experience with the first two, was sent to Wichita.

Initial B-29 production got under way at Wichita, where the fourteen service test YB-29s were built. The YBs and subsequent Wichita B-29s were built with Seattle Division model and serial numbers. Bell started production at Marietta as planned, but Martin at Omaha, Nebraska, was selected to replace the Fisher Body production at Cleveland, which was switched to subassemblies, and the Army traded the North American Kansas City plant to the Navy for the Boeing Renton plant, which the Navy had built for production of the PBB-1 Sea Ranger. All production of the B-29A model was at Renton. In addition to prime airframe assembly in these four plants, the largest aircraft sub-contracting programme ever undertaken was set up throughout the country for equipment and sub-assemblies.

Renton-built B-29A-5 with both sets of bomb bay doors open. (*Boeing Photo X-299*)

Since production aeroplanes were under construction before much of the equipment and installations had been perfected or even tested on the prototypes, they were deficient from the combat-readiness standpoint before they left the production line. Rather than hold up production of the following aircraft by stopping the line to incorporate the needed changes in the factory, the Army set up three modification centres at air bases in Kansas and at the Bell-Marietta and Martin-Omaha plants where the B-29s were modified and brought up to date. This work was hampered by the Army's lack of experience with the aeroplane, the need to work outdoors in winter blizzards, and difficulty in obtaining some of the necessary equipment and supporting tools. Boeing production personnel from Wichita and Seattle were drafted to reorganize the Army programme and assist with the work. The hectic six-week period of March 10–April 15, 1944, when the first B-29s for overseas service were modified under great stress and difficulty, is remembered as 'The Battle of Kansas'.

In spite of early standardization of B-29 defensive armament, experiments were made with other arrangements including manned turrets. Before war's end some B-29s had all but the tail armament removed as a weight and drag-saving measure. Fighter attacks from the front and side had ceased to be a serious problem.

The first B-29s were secretly delivered over the Atlantic via North Africa to India, with one sent openly to Europe as a feint. Along with their bases in India, the four groups of B-29s had advanced bases in China to which they had to fly their own fuel and supplies. Some B-29s were converted into tankers and others carried supplies in cargo racks inside the bomb bays. The first B-29 operation was a raid on Bangkok on June 5, 1944, from bases in India. Although the Japanese were aware of the presence of B-29s in the China-Burma-India theatre, the Bangkok raid was reported by Radio Tokyo as having been conducted by B-24s. The first raid against Japan was made from four Chinese bases on the night of June 15/16, when 47 B-29s, of 68 dispatched, bombed the steel mills of Yawata.

Long-distance strikes against Japan continued to be made from China with a fairly high attrition rate because of the combination of long distances over enemy-held territory, navigation and equipment problems, and the weather. Many B-29 crews abandoned ship or crash-landed in occupied China, some making their way to safety with the aid of loyal Chinese. Others landed in Soviet territory, where their B-29s were interned because Russia was not yet at war with Japan. These aircraft were copied faithfully and were produced in Russia as the TU-70 in early postwar years.

The B-29 offensive against Japan got into high gear when Western Pacific islands, the Marianas, which were closer to the targets, were captured and used as air bases. This allowed an eventual total of 20 groups to operate with lighter fuel loads and consequently greater bomb loads. The China-based B-29s were transferred to the islands in April 1945. First bombing operations from Saipan against Tokyo, 1,500 miles distant, were flown on November 24, 1944. In the initial raids, the B-29s had to make maximum

Enola Gay, Martin-built B-29 that dropped the first atomic bomb at Hiroshima on August 6, 1945, has been preserved for the US National Air Museum. (*1949 Photo by Peter M Bowers*)

use of their high-altitude capabilities to stay above anti-aircraft fire and the effective altitude of the defending fighters. Bombing was not too effective and losses were moderate. More B-29s became available in February, and in March a decision was reached to try night attacks from low altitude. The B-29s were loaded with incendiary bombs instead of high explosive. The total bomb load per plane was increased since they did not have to carry the great fuel loads needed for high-altitude operations and much armament was stripped out. One-quarter of the city of Tokyo was destroyed in a single raid on the night of March 8/9, 1945. After the February capture of Iwo Jima, an island nearly midway between Saipan and Japan, fighter escort became available to the B-29s in April. However, the Iwo-based fighters virtually put themselves out of business by eliminating the defending fighters and the B-29s roamed almost at will all over Japan to the point where they would drop leaflets on selected cities, telling the civilian population to leave the area before the scheduled attack.

World War II was brought to an end, without the necessity of an invasion

Bell-built B-29B modified to carry the Bell X-1, first aeroplane to exceed the speed of sound, for in-flight launching. (*Bell Aircraft Photo*)

After WW-II, the Russians copied and produced B-29s from examples that had made forced landings in Siberia. This Tupolev TU-70 is a transport version with a slightly enlarged fuselage. (*Boeing Photo P-7880*)

of Japan, by two B-29s that had a greater impact on subsequent world history than any aircraft including the Wright brothers' and Lindbergh's. The first, a B-29-35-MO named *Enola Gay* which was disguised with reconnaissance markings, dropped the first atomic bomb on Hiroshima on August 6, 1945. The second B-29, named *Bockscar,* dropped the second bomb on Nagasaki three days later.

V-J Day resulted in the cancellation of 5,092 B-29s still on order in the four plants in September 1945, although a limited number well along in production were completed. The last of 3,627 B-29s built, including the X and YBs, was delivered on June 10, 1946. B-29s continued to serve as standard bombers through the Korean war, and 87 were turned over to Great Britain under the designation of Boeing Washington in 1950. Postwar modifications for such special purposes as weather reconnaisance and aerial tankers extended the life of the basic B-29 for several years beyond its usefulness as a first-line bomber. The last WB-29s were retired in 1960. The cost of the B29 in service quantities is broken down as follows:

Airframe	$399,541.00
Engines	98,657.00
Propellers	10,537.00
Electronics	34,738.00
Ordnance	95,715.00
TOTAL	$639,188.00

The first XB-29 to fly, as originally equipped with three-blade propellers. This machine was used for aerodynamic and powerplant testing and was not fitted with armament. (*Photo by Gordon S Williams*)

MODEL 345 (B-29 series) – A single Boeing model number was used for all production versions of the B-29. Not counting the three XB-29s and the fourteen YB-29s, 3,957 B-29s, B-29As, and B-29Bs were built and delivered to the Army. Modification programmes resulted in series letters as high as T to indicate 18 configurations (no I or O) adopted or considered. Technical data for the representative B-29 is presented below, followed by paragraphs treating each B-29 series separately.

TECHNICAL DATA – B-29

Type:	Heavy bomber
Accommodation:	10 crew
Power plant:	Wright R-3350-23, 2,200 hp at 2,600 rpm
Span:	141.23 ft
Length:	99 ft
Height:	27 ft 9 in
Wing area:	1,739 sq ft
Empty weight:	69,610 lb
Gross weight:	105,000 lb (WW-II configuration). Increased to 140,000 lb on postwar modifications
Max speed:	365 mph at 25,000 ft
Cruising speed:	220 mph at 50% power
Service ceiling:	31,850 ft
Range:	5,830 miles
Armament:	Ten-twelve ·50 cal MG, one 20 mm cannon. Four 4,000 lb bombs, eight 2,000 lb bombs, twelve 1,000 lb bombs, forty 500 lb bombs, fifty 300 lb bombs, or eighty 100 lb bombs without modification

• XB-29 – Two XB-29 prototypes were ordered on September 6, 1940, along with one static test example. A third flyable XB-29 was ordered on December 14, 1940. Engines were R-3350-13 with 17-foot diameter three-blade propellers. Initial flights to prove out the aircraft were made without armament. First flight September 21, 1942.

C/ns:	2481, 2482, 2884
Army serial numbers:	41-3, -2, -18335 (note sequence)

YB-29, one of fourteen service test models built in Wichita. (*Boeing-Wichita Photo BW-15751*)

• YB-29 – Fourteen service test aircraft built at Wichita were fitted with standard armament and delivered in camouflage paint. Engines were R-3350-21, still using three-blade propellers. The first was turned over to General Motors for installation of liquid-cooled Allison V-3420 engines and further test as XB-39 while the remainder were used for various research and training programmes.

C/ns:	3325/3338
Army serial numbers:	41-36954/36967

• B-29 – The major production model of the Superfortress, built by Boeing at Wichita (1,620), Martin at Omaha, Nebraska (204), and Bell at Marietta, Georgia (357), for a total of 2,181. Principal outward difference from the test models was the use of 16 ft 7in diameter fully-feathering four-blade propellers. Minor variations were many, Boeing-Wichita models reaching Block Number 100 in increments of five and Martin and Bell reaching -60 and -65, respectively. Engines were R-3350-23. Only very early Wichita models were delivered in olive drab and grey camouflage paint. The rest were delivered unpainted, although a few had the under-surfaces and lower halves of the fuselage painted glossy black for night missions.Note mixing of low 1942 Army serial numbers among all three manufacturers.

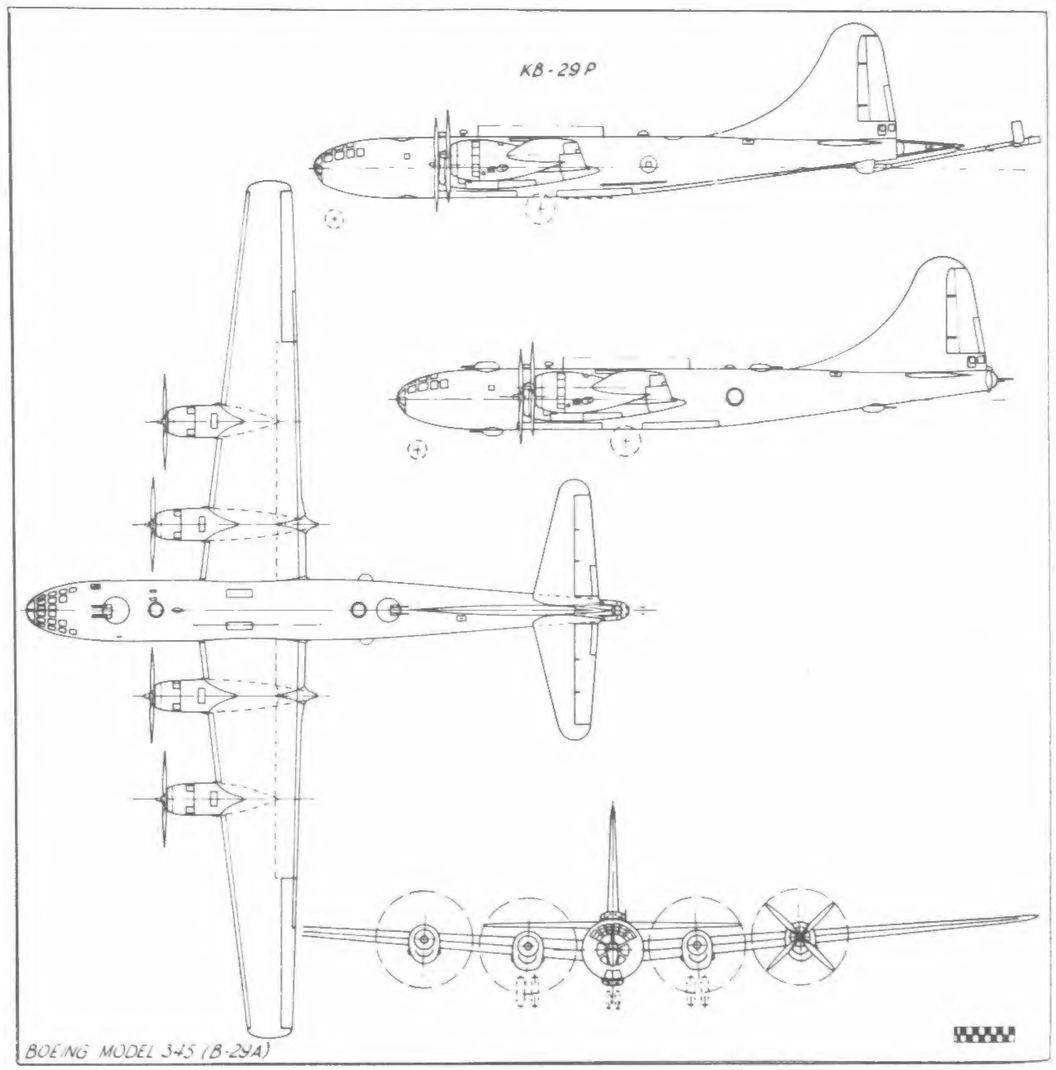
Models	*C/ns*	*Army serial numbers*
B-29-BW	3339/3355	42-6205/6221
B-29-BW	3357	42-6223
B-29-BW	3359/3362	42-6225/6228
B-29-BW	3368	42-6234
B-29-BW	3370	42-6236
B-29-BW	3372/3376	42-6238/6242
B-29-BW	3378/3538	42-6244/6404
B-29-BW	4081/4580	42-24420/24919
B-29-BW	10487/10986	44-69655/70154
B-29-BW	12387/12586	44-87584/87783
B-29-BW	13587/13766	45-21693/21872
B-29-MO	Unknown	42-6229/6232
B-29-MO	Unknown	42-6237
B-29-MO	Unknown	42-65202/65313
B-29-MO	Unknown	42-65314/65401
B-29-BA*	Unknown	42-6222, 6224, 6233, 6235,6243
		42-6335 2/63580
		42-63737, 63744, 63751
		44-83894/84139
		44-84141/84149
		44-84151,84152, 84155,84156

*Includes B-29B-BA.

• B29A – Outwardly the B-29A, built at Renton and using the identification symbol BN to indicate manufacture in the Navy-owned plant, could be

distinguished from the B-29 only in having four guns instead of two in the front turret. There was significant structural difference in the wing, however. Where the B-29 employed a two-piece centre section bolted together at the centre line, which was installed as a single unit passing entirely through the fuselage and supporting the engine nacelles, the B-29A used a very short stub centre section that projected only a short distance beyond the fuselage sides. Each pair of nacelles was fitted to a separate short section of wing. The outer wing panels attached at the same point on B-29s and B-29As alike. Revised engine nacelles, named *Andy Gump* for the cartoon character because the 'chin' was made very inconspicuous by moving the oil coolers and intercoolers aft, were developed and tested and were to have been used on later B-29As. Block numbers for the 1,119 B-29As reached -75, with R-3350-57s.

C/ns	*Army serial numbers*
7231/7530	42-93824/94123
10987/11805	44-61510/62328



The B-29As were built only at Renton. This is a B-29A-45 with the streamlined four-gun upper forward turret of very late B-29As. (*Boeing Photo P-10331*)

• B-29B – A total of 311 Bell-built B-29s were lightened by stripping out all but the tail defensive armament, since experience had shown that the only significant attacks had to be from the rear. The guns were aimed and fired automatically by the new AN/APG-15B radar fire control system that detected the approaching target and made all the necessary calculations. Elimination of the turrets increased the top speed to 364 mph at 25,000 ft and made the B-29Bs well suited for fast unescorted hit-and-run bombing raids and photographic missions. Much of the weight saved by stripping was devoted to additional bomb capacity without decreasing fuel load or exceeding gross weight limitation.

The B-29Bs were not ordered in a single large block but were taken in small batches, sometimes as single aeroplanes, from B-29-BA production. Consequently, the individual Army serial numbers are too numerous to list here conveniently. The external radar and absence of machine-gun turrets makes it possible to identify wartime B-29Bs without the serial number.

MODIFIED B-29s

B-29B was the highest designation assigned to a production B-29 model. Although B-29D was intended to be a production version, the designation was not used. All higher designations were assigned as a result of modifications that recognized the basic bomber configuration.

Wichita-built B-29-35 was used in Seattle to test electrical systems, new 'Andy Gump' engine nacelles for late-model B-29As, and the higher vertical tail of the B-50. (*Boeing Photo P-7468*)

B-29Bs were stripped versions of Bell-built B-29s that used only radar-controlled tail guns. Black undersurfaces were standard for night operations. (*Photo by Peter M Bowers*)

• B-29C – This designation assigned to one B-29 to use improved R-3350 engines, but the project was cancelled.

• B-29D – A greatly improved model, using 75 ST alloy construction and P & W R-4360 engines. Built as B-50A (see page 346).

• XB-29E – One converted aircraft used for fire control system testing.

• B-29F – Six B-29s winterized for cold weather testing in Alaska and eventually reconverted to standard B-29-BW.

This B-29F was one of six B-29-45-BWs redesignated for cold weather evaluation. (*USAF Photo*)

• XB-29G – Bell-built B-29 44-84043 was modified as a test bed for General Electric turbojet engines. The engine was mounted on a pantagraph in the bomb bay and could be extended below the XB-29G to operate in a fast airstream unattainable in ordinary test cells.

The single XB-29G was a Bell-built B-29B-55 used as a flying engine test laboratory. Note General Electric jet engine extended from modified bomb bay. (*General Electric Photo 1023531*)

Pacusan Dreamboat set non-stop distance record of 7,916 miles from Guam to Washington, D.C., in November 1945 as a B-29B. Refitted with modified nacelles intended for late-model B-29As, fuel-injection engines, and special propellers, it was later redesignated YB-29J. (*Photo by Gordon S Williams*)

• XB-29H – One B-29A used for special armament testing.

• YB-29J – Approximately six B-29s were fitted with R-3350-CA-2 fuel injection engines and the revised 'Andy Gump' nacelles intended for late Model B-29As to service test the new installations. Some were used for photo-reconnaissance work as RB-29J and two (44-86398, 86402) were eventually converted to tanker aircraft as YKB-29J in the KB-29P programme while retaining the service test and J-series designations.

• B-29K – This was the original designation assigned to the hose tanker B-29s that were produced as KB-29M. Since none of the tankers used the original designations, the K suffix was assigned to a single B-29-BW used as a cargo transport and designated CB-29K.

• B-29L – Designation originally assigned to B-29 aircraft to be adapted as receivers for the British-developed hose in-flight refuelling system. The reorganization of the political map of the world in the early postwar years produced a greater demand for bombers. Since the bomber force was made up almost entirely of basic WW-II types, a way had to be found to increase their range without sacrificing effective military load. A special B-29B, the *Pacusan Dreamboat* (44-84061) fitted with 'Andy Gump' nacelles and three-blade propellers, had made several record-breaking long-distance flights

Two of approximately six YB-29Js used to test new fuel injection engines were fitted with KB-29P aerial refuelling booms but were redesignated YKB-29J. (*Photo by Gordon S Williams*)

B-29MR hose receiver (below) being refuelled by a KB-29M. (*Boeing Photo 2B-3432*)

shortly after the war, but was virtually a flying fuel tank and useless as a bomber at such ranges. The British had developed a method of refuelling standard transport aircraft on the North Atlantic run with a hose lowered from a tanker aeroplane. Since the British system was superior to that used by the US Army in its famous 150 hr record endurance flight with the Fokker trimotor *Question Mark* in January 1929, the Air Force obtained this equipment for installation in B-29s and B-50s. The B-29L designation was not used for the receiver aircraft, which became B-29MR.

• KB-29M – A total of ninety-two B-29s were converted to tankers in the

The 'Flying Boom' developed for the KB-29P. This was controlled by an operator stationed in the former tail turret location. (*Boeing Photo P-12881*)

EB-29 44-62205, the only B-29 equipped as a boom receiver. The white paint is a special application intended to show the flow of spilled fuel when using dyed water in tests. (*Boeing Photo A-34825*)

Wichita Boeing Plant 2, which had been reopened for the purpose in 1948. In addition to the hose and power-driven reel in the aft fuselage, each bomb bay was fitted with a separate jettisonable tank holding approximately 2,300 gal. These tanks were connected to the normal aeroplane fuel system so that fuel from it, too, could be transferred to the receiver aeroplane.

Procedure called for the tanker and receiver aircraft to fly in formation with the tanker above and ahead and trailing a cable called the hauling line. The receiver trailed another line from its refuelling receptacle that was called a contact line. A grapnel on the end of this line engaged the hauling line during a crossover manoeuvre, after which a winch in the receiver wound in both lines. The receiver operator reached through a port and separated the two lines when the grapnel was pulled up to the mouth of the receptacle, after which he attached the hauling line to the winch and used it to pull the hose from the tanker. After the nozzle was seated in the receptacle (located under the tail on the starboard side of the fuselage (see page 348)), and locked with hydraulically-operated toggles that would release at a predetermined pull on the hose, a signal was sent to the tanker, which was now above and behind, to indicate 'Contact Made'. Fuel pumps in the tanker accelerated flow to the receiver, which had a 2,500 gal tank

A YKB-29J refuels a Republic F-84G through receptacle in port wing root. (*USAF Photo*)

installed in the aft bomb bay. Incoming fuel could also be directed to other tanks in the regular fuel system.

• B-29MR – Although the aft bomb-bay tank was the only feature common to both tanker and receiver B-29s, the 74 receivers were also designated B-29M, the receiver function being designated by the additional suffix letter R, as B-29MR.

• B-29N – Designation not known.

• KB-29P – The hose refuelling system had obvious limitations, especially in the time to make contact, the slow rate of fuel transfer, and the limiting airspeed imposed by the hoses. Boeing set out to eliminate the problems and soon developed an aerodynamically-controlled swivelling and telescoping arm known as the Flying Boom. This was controlled entirely by an operator in the former tail turret location in the tanker, who 'flew' the boom nozzle into a receptacle on the top of the receiver fuselage. The boom operator immediately received the nickname of 'Clancy' throughout the Air Force because of the catchline in the classic American ballad, 'Clancy Lowered the Boom'. Aerodynamic control was by means of surfaces called ruddevators that served the dual function of rudders and elevators to control the boom in aximuth and elevation. Extension and retraction of the nozzle was accomplished hydraulically. The pilot of the receiver had to keep the nose of his machine within a prescribed envelope to maintain contact, and was assisted in the trying job by a series of indicator lights along the belly of the tanker that were connected to limit-switches in the base of the boom and directed the pilot to correct his position by different coloured lights and the words 'Right', 'Left', 'Up', 'Down', 'Fwd', and 'Aft'. The boom system was also used to refuel fighters, but a variation of the hose system, using a drogue on the end of the hose that was engaged by a probe on the nose of the fighter, proved to be more satisfactory for the smaller aircraft. Some boom tankers were adapted to the new system by installing a short length of hose and a drogue on the end of the boom. To meet the demand for boom tankers, the remainder of the Renton plant, part of which had been opened

The single YKB-29T, a KB-29M converted to three-hose configuration in England, refuels three RAF Gloster Meteor fighters simultaneously. (*Boeing Photo*)

The first YB-29 was turned over to General Motors for flight testing of experimental Allison V-3420 liquid-cooled engines and was redesignated XB-39. (*USAF Photo*)

for C-97A production, was reopened and 116 B-29s were converted to KB-29P in 1950–51.

• B-29Q – Designation unknown.

• B-29R – Designation unknown.

• YKB-29T – A single KB-29M (45-21734) was converted to a three-hose tanker that could refuel three fighters simultaneously. One hose was installed in the tail while the two others were installed on reels mounted in pods hung under the wingtips. Since later jet fighters and bombers did not have slow-flight characteristics that were compatible with the now thoroughly obsolete B-29, the triple-hose arrangement was used on later B-50 tankers.

REDESIGNATED AND SPECIAL PURPOSE B-29s

Many different designations were applied to B-29 aircraft for the same reasons specified for the B-17 on page 305.

• XB-39 – The first YB-29 (41-36954) was turned over to General Motors for use as a test bed for new Allison V-3420 liquid-cooled engines. These were essentially pairs of the standard Allison V-1710 fighter engines combined on a common propeller shaft to deliver 2,600 take-off horse power. Normal output was 2,100 hp at 25,000 ft, but the engines were not ready for production. While aeroplane speed increased to 405 mph at 35,000

The single XB-44 was a B-29A-1 fitted with 28-cylinder R-4360 engines in redesignated nacelles by Pratt & Whitney. Production version to have been B-29D became B-50. (*Boeing Photo 96035*)

ft, overall performance was not sufficiently improved over the existing air-cooled R-3350s to justify further conversions.

• XB-44 – The requirement for additional power for improved B-29s was met by the appearance of the four-row 28-cylinder P & W R-4360 engine. Development for the complete installation of this engine in the B-29 was entrusted to Pratt & Whitney, which was given B-29A 42-93845 as the test bed. This aircraft was redesignated XB-44, and was easily recognizable by the new engine installations. Initial orders for the improved B-29, to be known as B-29D, were cancelled, but were later reinstated as B-50A. Because of the assignment of the XB-44 to P & W and the work that the New England firm did on it, the XB-44 appears in some records as a P & W, rather than a Boeing, aeroplane.

• F-13 – One B-29-BW (42-6412) was redesignated F-13 when used primarily for photo-reconnaissance missions with special camera installations in addition to the standard bombing equipment and defensive armament. An additional 117 B-29-BWs and B-29As were similarly modified as F-13 to carry three K-17B, two K-22, and one K-18 camera with provision for others. The F-13s were redesignated RB-29 and RB-29A in 1948.

F-13As were former B-29As with special photo equipment in the fuselage and forward bomb bay. F-13s were redesignated RB-29 in 1948. (Photo by Peter M Bowers)

P2B-1S was the US Navy designation assigned to four B-29s obtained after WW-II. One was used to air-launch rocket-powered Douglas D-558-II research aircraft. (*Boeing Photo 125110*)

SB-29 designation was assigned to B-29s converted to search and rescue missions. Lifeboat could be dropped by parachute to survivors spotted at sea. (*Boeing Photo 139630*)

War-surplus B-29 in long-term storage is protected from the elements by a sprayed-on plastic cocoon. (*Gordon S Williams Photo*)

• P2B-1 – This designation was originally assigned to the Boeing Model 209 of 1929, an improved version of the PB-1 flying-boat of 1925. Even though the machine was not built, the Navy seldom re-assigned a designation once it had been assigned. On March 14, 1947, the Navy took over four B-29-BWs for long-range search missions and assigned the designation of P2B-1S. Later, one was modified for the Navy tests of the Douglas

RAF assigned the name Washington I to eighty-seven B-29s obtained on loan from 1950 to 1955. (*Crown Copyright*)

D-558-II high-speed research rocket plane, which was carried by the modified bomber for drop-launching.

Navy serial numbers	*Former Army serial numbers*
84028	45-21789
84029	45-21787 (N91329)
84030	45-21791
84031	44-87766

• WASHINGTON – To meet postwar British long-range bomber requirements until the new Avro Lincoln could be delivered in quantity, 87 standard B-29s were loaned to the RAF, which renamed them Washington. The loan was made in March 1950 and the B-29s returned by 1955.

RAF serial numbers
WF434/448
WF490/514
WF545/574
WW342/355
WZ966/968

(See Appendix VII for correlation of USAF and RAF serial numbers.)

EXTENDING FIGHTER RANGE

Shortly after the Second World War two interesting experiments were undertaken with the object of enabling short-range jet fighters to accompany bombers to the target area by being carried there by a B-29.

The first involved a tiny fighter, the McDonnell XP-85, that had been designed specifically to be carried in the modified bomb-bay of a B-29. Flight tests were conducted, but the XP-85 was an inadequate aeroplane

McDonnell XP-85 approaching modified B-29B-65-BA for hook-up to trapeze lowered from rear bomb-bay. (*McDonnell Photo D4E-11094*)

Two Republic EF-84Bs attached to the wingtips of an EB-29A as part of an experiment to extend the range of jet fighters by towing them. (*USAF Photo*)

and the scheme, while barely workable, was considered to be impractical and was discontinued.

A different arrangement was tried with standard production Republic F-84B fighters. Two EF-84Bs were used, one flexibly attached to each wingtip of an EB-29A so that it could be towed by the B-29 and later released. The tests were unsuccessful and that scheme, too, was abandoned.

POSTWAR CIVIL OPERATIONS

Unlike most models, B-29s were not available on the immediate postwar surplus market or at any time thereafter. A few, however, were flown with civil registrations under rather unusual circumstances.

Only one flyable B-29, the former P2B-1S 84029 used by the Navy to carry the Douglas D-558-II research aircraft and later by the NASA, was sold directly to a civil owner, a recognised aviation museum in Oakland, California. This B-29, c/n 13681, was flown on rare occasions on an experimental civil licence with registration N91329. After many years of inactivity, it was sold to the Kermit Weeks Aviation Museum of Miami, Florida, and was transported there disassembled in 1987. It was registered N29KW.

In the 1970s, as the demand for Second World War aeroplanes for museum displays intensified, the US Air Force received many appeals for suitable articles, particularly B-29s. The Air Force assured the applicants that all of the B-29s were out of the inventory and that none was left in any condition other than those already on display at official Air Base museums. Unknown to officialdom, however, there was a large cache of relatively intact B-29s on a remote US Navy gunnery facility in the western desert –

Fifi is a B-29 restored from junk by the Confederate Air Force and is flown regularly in air shows by that organization. (*Photo by Ken Sumney*)

China Lake, California. They had been placed there years before as gunnery targets and had then been forgotten by all concerned.

After interested parties found out about these derelict B-29s, serious efforts were made to obtain some. After much paperwork, this was accomplished. Two were made flyable by scrounging parts from several of the hulks on-site. One, 44-62070, c/n 11547, was acquired by the Confederate Air Force of Harlingen, Texas, and is flown regularly in its air shows with civil registration N529B. The other, 44-61748, c/n 11225, was donated by the Navy to the Imperial War Museum at Duxford in England and was flown across the Atlantic with British registration G-BHDK in March 1980. Others have been taken from the site in pieces for subsequent reconstruction and non-flying display at private and Air Force Base museums, and one, supposedly flyable, appears on the US civil register as N3299F, c/n 11146, formerly 44-61669, registered to Yesterday's Air Force. One complete non-flyable B-29 was donated by the US government to the government of South Korea and is currently on display in Seoul.

Chapter 10

AFTER WORLD WAR II

Chronologically, the second postwar period of aviation, which saw the phasing-out of most traditional propeller-driven military designs, coincides with the opening years of the Jet Age. However, because of the great differences in design concept, structure, and operations of the aircraft, the overlapping years of the two eras are discussed separately.

By the end of 1944 it was obvious that Germany could not wage war much longer and that the major Allied effort would soon be concentrated in the Pacific. The effects of subsequent planning were quickly felt in the American aviation industry. B-17 production was phased out at Boeing and the other B.V.D. plants and was actually completed a month before the end of hostilities in Europe, known as VE-Day.

Even earlier, however, Boeing had devoted attention to the problems of postwar survival. Recognizing that there would be only a relatively small civil market for the type of aeroplane in which it specialized, Boeing conducted extensive surveys into other product lines that could be turned out in existing facilities, including boats, metalware, and even automobiles. The lessons of the post-WW-I furniture and boat-building enterprises were well remembered, however, and it was realized that with any of these new products the company could be competing with specialized industries that had been in the business for years, knew the market, and had well-established distribution organizations. Except for interceptor rockets and a small gas-turbine engine, no non-airframe work was undertaken in the immediate postwar years.

Between VE-Day and the unexpected arrival of VJ-Day, all Boeing facilities concentrated on increasing B-29 production and on the development of new designs for the Pacific war, which had been expected to continue until such time as the Japanese home islands were softened up by aerial bombardment to the point where they could be invaded by traditional seaborne forces. The sudden ending of hostilities by use of the atomic bomb caught Boeing and the rest of the aircraft industry by surprise and the cancellation of most military production orders precipitated a crisis in industries that did not have peacetime products ready for production.

Boeing proved to be in a somewhat better position than other large airframe manufacturers during the first postwar year. While there had been complete cancellation of the B-29 programme, with only those in an advanced stage of construction being completed, other contracts were in hand that would keep the Seattle plant partially occupied for almost two

Three experimental Stratocruisers photographed at the Wichita plant, where part of the certification programme was conducted. Model 377-10-19 in the foreground later became the last 377-10-26. (*Boeing Photo 37844*)

years after the war. There was a 10-plane order for service test versions of the XC-97, a transport developed during the war from the B-29 in the same manner that the Model 307 Stratoliner had evolved from the B-17. Airline orders for the commercial equivalent of this transport eventually totalled 55. While the contract for the heavy XF8B-1 Navy fighter was completed following delivery of the three prototypes, the design and production of an improved version of the B-29 continued. Follow-on orders kept the B-50, as the new model was called, in production until 1953.

All production plants shut down completely for a short time following VJ-Day and most of the temporary wartime work force of housewives and farmers returned to their homes. The Seattle plant soon reopened and reached a strength of 9,000 experienced engineering, administrative, and shop personnel by the end of 1945. This total grew to 17,000 by the end of 1947. While Plant 1 remained open, Renton was closed after completion of B-29 work in 1946 and the government-owned facilities were taken over by the Navy for the storage of surplus flying-boats and other equipment. Plant 2 at Wichita also reverted to the government and only a skeleton staff was kept on in the original Stearman plant to develop new models.

The transition from wartime to peacetime production was well under way by 1947, even though the major contracts were military. That year saw four new aircraft models make their first flights – the commercial Model 377 Stratocruiser developed from the C-97, the Wichita-designed XL-15 Scout Army liaison aircraft (Boeing Model 451), the redesigned B-29 that became the B-50, and the radically new XB-47 jet bomber (Boeing Model 450 Stratojet, see Chapter 11). The Seattle plant was in full production on the B-50s, the Stratocruiser, and the ten YC-97s, and Wichita had obtained a service test order for ten YL-15s and had reached the mockup stage on the Model 417, a small feeder-line transport. On December 31, 1947, the Boeing Aircraft Company readopted the name Boeing Airplane Company that it had used from 1917 to 1934.

In 1948 an increase of military business had a far-reaching effect on the company. Orders for production versions of the service test YC-97A had been received in Seattle. With Plant 2 full of B-50s and Stratocruisers, the

space for C-97 production was obtained by reopening part of the Renton plant. To extend the range of the existing B-29 bomber fleet, the Army Air Force, just then in the process of becoming the US Air Force, a separate and co-equal branch of the Armed Forces, asked Boeing to install British-developed inflight refuelling equipment in B-29s (see Chapter 9). Facilities for this production-line job were provided by reopening the government plant at Wichita.

The British in-flight refuelling system, which required the receiver aircraft to catch and attach a hose lowered by the tanker, had inherent disadvantages that Boeing felt could be eliminated. The company soon developed a 'Flying Boom' system of its own that not only simplified the operation but permitted higher aircraft formation speeds, a faster rate of fuel transfer, and was compatible with single-seat receiver aircraft. The Air Force accepted the new system, but since the Wichita plant had completed the hose tanker programme and was then tooling up for B-47 production, a new B-29 modification line was established in the unused portion of the Renton plant. After the order for KB-29P tankers was completed in 1950, the tanker role was assigned to the faster and more powerful C-97, which was more compatible with the B-50s that had largely replaced the wartime B-29s in the bomber force. The new tanker, identified as KC-97, became the major production model of the series. The C-97s were the only aeroplanes actually built at Renton between the end of B-29 production in 1946 and the development of the Model 367-80 jet transport prototype in 1954.

At Plant 2, B-50 production filled the gap between the completion of the Stratocruisers early in 1950 and the start of B-52 jet bomber production in 1953 (Boeing Model 464 Stratofortress, see Chapter 11). As orders for B-52s increased, a second production line was set up in the Wichita plant in 1954. Seattle B-52 production ended in 1959 and engineering responsibility was transferred to Wichita. Wichita was kept busy after the completion of B-52

The first airborne installation of the Boeing Model 502 gas-turbine was in the XL-19B, an experimental conversion of the well-known Cessna L-19A liaison aircraft. (*Boeing-Wichita Photo BW-90287*)

production contracts in 1962 by Air Force contracts for modernization of the older B-52s to fit new mission concepts.

Even before the last of these giants was built, it was evident that the era of the big bomber was coming to an end, and with it the end of the postwar boom in large military aircraft. An era of austerity faced the entire aircraft industry; the Boeing Seattle plant had stood empty except for sub-assembly work since delivery of its last B-52F and only the Renton plant continued to build aeroplanes after Wichita production ended. In spite of large-scale transfers into missile projects, employment, which had reached a Seattle/Wichita/Vertol peak of 106,483 in 1962, was down to 90,000 by April 1964.

Even when the airframe business was at its postwar peak, Boeing was active in developing other products, as were other long-established airframe manufacturers, some to the point where they got out of aviation entirely. Boeing developments included the gas-turbine engine, mechanical and electronic devices built to order for other Boeing and outside organizations, computers and even hydrofoil boats. Production orders for Air Force missiles, originally ordered under aircraft designations, and built in a former Seattle automobile assembly plant that became the Missile Production Centre (MPC), provided the first big step into the space age.

Additional product diversification was undertaken in 1960 with acquisition of the Vertol Aircraft Corporation of Morton, Pennyslvania, and its establishment as a new division of the Boeing Airplane Company. The word Vertol was an acronym for the words Vertical Take-Off and Landing to indicate the outstanding characteristics of the helicopter. Prior to 1956 the Vertol organization had been the Piasecki Helicopter Corporation, named after founder Frank Piasecki. From its founding in 1942 to 1946 it was known as the P-V Engineering Forum. The acquisition of Vertol resulted in a new Boeing Aircraft of Canada, for Vertol had maintained an overhaul and modification plant at Arnprior, Ontario. As had been the case with the Stearman designs when that company became a Boeing Division, the original Vertol model designations were retained. The Boeing/Vertol helicopters are not illustrated in this book.

The diversification of Boeing product lines and the division of the airframe business into distinctly civil and military lines resulted in several reorganizations of the Boeing corporate structure after 1950. An Industrial Products Division was formed in 1952, primarily for the manufacture and exploitation of the gas-turbine engine. This was renamed the Turbine Division in August 1964. The missile projects were consolidated in a separate Pilotless Aircraft Division in 1953. Those portions of the Seattle plant concerned primarily with aeroplanes became the Seattle Division in January 1956, while the Renton facilities became the Transport Division and Wichita retained its status as the Wichita Division. In May 1961, the Boeing Airplane Company changed its name to The Boeing Company. The Seattle and Wichita Divisions were combined into a new Military Aircraft Systems Division (MASD) four months later. In August 1959, a further reorganization combined the Seattle and Pilotless Aircraft Divisions and the

Systems Management Office into a new Aero-Space Division made up of Seattle Plant 2, the Development Centre, and the MPC facilities and joined the Wichita and Transport Divisions in a new Airplane Division. The Boeing Field Flight Test Centre and the commerical delivery centre remained under Airplane Divisional control.

At the end of 1964, The Boeing Company consisted of four divisions – Aero-Space, Airplane, Turbine, and Vertol. In January 1965, the Airplane Division was divided by the nature of its products into the Commercial Airplane Division and the Military Airplane Division. A further division took place in July 1965, when the Aero-Space Division was separated into the Missile and Space Divisions.

MODEL 345-2 (B-50A, B-50B) – This postwar production model was originally designated B-29D when an order for 200 was placed in July 1945. The quantity was reduced to 60 by the VJ cancellations, and the designation was changed to B-50 in December. The redesignation was an outright military ruse to win appropriations for the procurement of an aeroplane that by its designation appeared to be merely a later version of an existing model that was being cancelled wholesale, with many existing examples being put into dead storage. The justification given was that the changes, which were considerable, amounted to a 75% new aeroplane. As it was, the B-50 was conspicuous in being a lone piston-powered model in the postwar series of jet bombers. With one exception, everything from the B-43 on was a jet. The only new piston design developed since the B-29 was Convair's giant B-36, the others being modifications of established designs.

Few of the changes in the B-50 were noticeable from the outside. The major change was the switch from the traditional 24 ST aluminium structure to the newer 75 ST, which resulted in a wing that was not only 16% stronger than the otherwise identical B-29 wing but was over 600 pounds lighter. The change to 3,500 hp four-row 28-cylinder P & W R-4360 engines gave a power increase of 59%. Increased weight resulted in larger flaps and a higher vertical tail, which could be folded down to permit storage in average Air Force hangars. Other refinements were hydraulic rudder boost and nose wheel steering, faster-acting ball-screw undercarriage retracting mechanism, and electrical de-icing of the pilots' windows through the use of conductive NESA glass. The wings and empennage were de-iced thermally by having the exhaust from three combustion heaters, one in each outboard engine nacelle and one in the base of the vertical fin, flow through hollow double-wall structures in the leading edges of the surfaces. Reversible-pitch propellers allowed the use of engine power as an aid to braking on short or wet runways.

The first B-50 was a production article, and one of the first to reflect the new Air Force policy of assigning the A series suffix to the first production model of a new series. Since it was originally to have been built at Renton, the official designation was B-50A-BN, which was changed to -BO when the aeroplanes were actually built in Seattle Plant 2. The major new

B-50A was the designation assigned to a greatly-improved Model 345-2 that was originally to have been the B-29D. (*Boeing Photo P-6943*)

features, however, had been thoroughly tested on other B-29s, the high tail on B-29-35-BW (42-24528) which had been assigned to Seattle Experimental Flight Test and the new power plant installation on a B-29A-5-BN that had been redesignated XB-44 because of the major alterations. This aeroplane appears on some records as Pratt & Whitney XB-44 because it was assigned to that plant, which engineered and installed the entire power package.

In spite of the initial cutback, follow-on B-50 orders brought the total to 371 and maintained production until 1953. The last machine on the first order was held back and modified to YB-50C, intended to be the prototype of a further improved B-54A. Orders were placed for forty-three B-54A and RB-54A aircraft, but were cancelled along with the partially-built YB-50C when it became obvious that the piston-powered bomber had reached the peak of its development and was soon to be replaced by the jet. As they became obsolete and were replaced by jets, most of the B-50s were converted to hose tankers. Some that survived as WB-50 weather reconnaissance aircraft were retired in 1964, but several RB-50s were still in use with the mapping and charting service after that date. The cost of B-50s ranged from $1,144,000 to $1,485,000.

• B-50A – The first B-50A flew on June 25, 1947. Fifity-nine machines were completed as standard bombers, with block numbers -1 to -35, the sixtieth being held for modification to YB-50C. After a short time in service, fifty-seven B-50As were sent to the newly-opened Wichita plant to be modified for extended range through the installation of the British-developed hose tanker in-flight refuelling system described in Chapter 9. Using this system, B-50A 46-10 made the first non-stop flight around the world between February 26 and March 2, 1949, being refuelled by four pairs of KB-29Ms en route and taking 94 hr for the 23,452 mile journey. Eleven B-50As on the first contract were later modified to TB-50A and as obsolescence approached, all surviving examples were converted to KB-50J three-hose tankers by Hayes Industries.

TECHNICAL DATA – B-50A

Type:	Medium strategic bomber
Accommodation:	12 crew
Power plant:	P & W R-4360-35 3,500 hp
Span:	141 ft 3 in
Length:	99 ft
Height:	32 ft 8 in
Wing area:	1,720 sq ft
Empty weight:	81,050 lb
Gross weight:	168,708 lb
Max speed:	385 mph at 25,000 ft
Cruising speed:	235 mph
Service ceiling:	37,000 ft
Climb:	2,225 ft/min
Range:	4,650 miles
Armament:	Twleve ·50 cal MG, one 20 mm cannon, 20,000 lb bombs
C/ns:	15722/15780, 15782/15801
USAF serial numbers:	46-2/60, 47-98/117

B-50B was outwardly identical to B-50A. The first article was tested briefly as EB-50B with tread-type landing gear in place of conventional wheels. Note 'Buzz Number'. (*Boeing Photo 108940*)

• B-50B – The second B-50A contract included 45 improved versions to be designated B-50B, with gross weight increased to 170,000 lb. The first was retained at the factory for test work under the designation of EB-50B, and at one time was fitted with a track-tread undercarriage in place of conventional wheels. All other B-50Bs were sent to Wichita for modification to RB-50B, in which a reconnaissance capsule containing photographic and electronic equipment and extra crew members was carried in the rear bomb bay. Range was extended by installation of the British hose refuelling system and two 700 gal auxiliary fuel tanks under the wings. Forty-three RB-50Bs were converted to other specialized reconnaissance configurations before ending their careers as KB-50J tankers.

The B-50B introduced a significant change in the block number system. Instead of starting the blocks over at -1 for the new series, the B-50B block numbers simply continued from where the B-50A blocks had ended,

starting with B-50B-40 and continuing to -60. Subsequent production B-50s continued this new practice.

C/ns: 15802/15846 *USAF serial numbers:* 47-118/162

MODIFIED B-50Bs

Forty-three B-50B aircraft were redesignated as indicated below when they were fitted with special installations soon after initial delivery to the Air Force.

• RB-50E – Fourteen RB-50Bs modified at Wichita for special photographic missions.
USAF serial numbers 47-119, 120 122/132, 135

• RB-50F – Fourteen RB-50Bs modified at Wichita with SHORAN navigational radar for special missions.
USAF serial numbers 47-121, 134, 137/142, 144, 146,158/160, 162

• RB-50G – Fifteen RB-50Bs similar to RB-50F but with additional radar equipment and B-50D type nose.
USAF serial numbers 47-133, 136, 143, 145, 147/154, 156, 157, 161

MODEL 345-9-6 (B-50D) – This marked a major change in the B-50 series and justified a revised factory designation. Most noticeable outward change was a revised nose with a single large moulded plastic cone and an optically-flat bomb-aimer's window in the lower portion instead of the seven-piece B-29 unit used through the B-50B. Gross weight was increased to 173,000 lb and range was extended by installation of receptacles for the Boeing-developed boom-type in-fight refuelling system starting with the sixteenth aeroplane. Two 700 gal auxiliary tanks could be carried on pylons under the outer wing panels or a 4,000 lb bomb could be substituted for each tank. These changes raised the cost of the B-50D to $1,444,300. B-50D block numbers were -65 to -125.

C/ns	*USAF serial numbers*
15847/15854	47-163/170
15855/15921	48-46/112
14994/16008	48-113/127
16036/16167	49-260/391

MODIFIED B-50Ds

In addition to service as first-line bombers, some B-50Ds were diverted to contemporary test work intended to improve the design. As the B-50 fleet aged and was replaced by later designs the aeroplanes were converted for useful work other than bombing.

• DB-50D – One B-50D converted to a drone director for testing of the Bell XGAM-63 missile.

• JB-50D – One WB-50D given temporary J-designation while used for experimental work.
USAF serial number 49-310

Close-up of B-50B showing hose refuelling receptacle beneath the horizontal tail. (*Boeing-Wichita Photo BW-40964*)

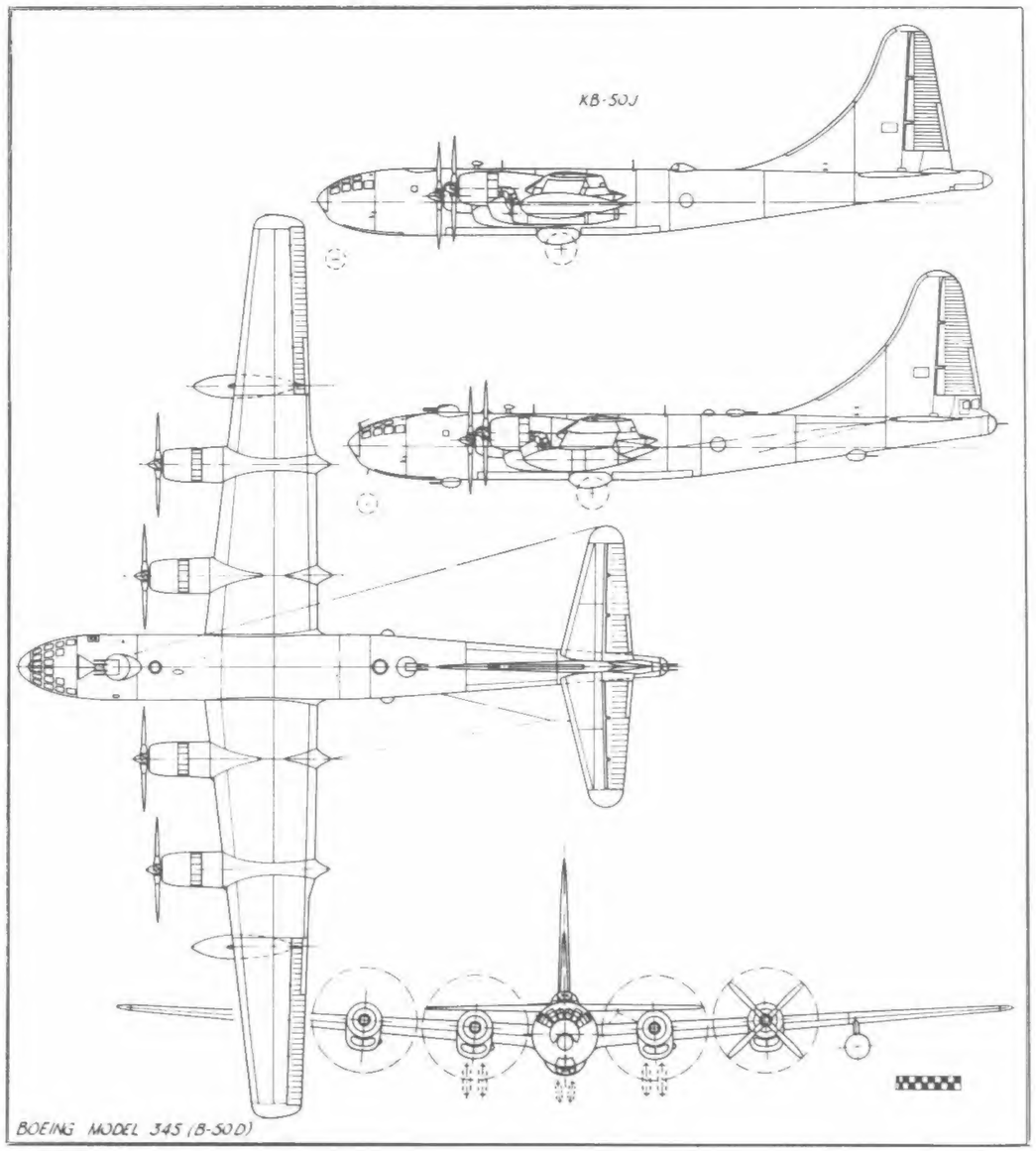
• KB-50D – Two B-50Ds modified to serve as prototypes for subsequent KB-50J and KB-50K programmes.
USAF serial numbers 47-170, 48-46

• TB-50D – Eleven B-50Ds were stripped of all armament and converted to TB-50D aircrew trainers.
USAF serial numbers 47-163, 164, 167, 170, 48-46/52

• WB-50D – Thirty-six obsolescent B-50Ds were stripped of their armament and equipped for long-range weather reconnaissance missions using meteorological equipment including high-altitude atmospheric samplers, doppler radar, weather radar, and a bomb-bay fuel tank for extended range. The last WB-50D was retired in 1967 and replaced by a WB-47.
USAF serial numbers 48-73, 105, 108, 113, 116, 121, 124, 49-260, 261, 264, 266, 281, 284/288, 291, 296, 298, 300, 302, 304, 310, 311, 313, 324, 332, 333, 337, 341, 345, 351, 371, 375

B-50Fs were B-50Bs converted for special SHORAN missions. Wing tanks from B-50D. Note removal of red Arctic Marking colour from fabric areas. (*Photo by Gordon S Williams*)

Original external recognition feature of B-50D was addition of 700 gal fuel tanks under the wings, use of flying boom system of aerial refuelling. (*Boeing Photo P-12159*)



TB-50H was a radar bombing-navigation trainer lighter and faster than standard models because no gun turrets were fitted. (*Boeing Photo P-12768*)

MODEL 345-31-26 (TB-50H) – B-50 production was completed with 24 unarmed bomber-navigation trainers intended to familiarize specialized crews with the use of new 'K' system radar bombing and navigation techniques developed for the B-47. Additional crew stations were provided for two students and an instructor and the rear bomb bay was packed with the electronic gear. Bombs could be carried in the forward bomb bay, which remained functional, but an actual drop was not necessary to crew training. A signal was transmitted at the moment of the theoretical drop and was scored by ground radar that was following the operation. Since the training missions were of relatively short range, no provision was made for in-flight refuelling. Because of the lighter weight (120,000 lb) the TB-50H was the fastest production B-50, with a top speed of 418 mph at 31,000 ft. All TB-50Hs were delivered between September 1952 and March 1953 and did not use block numbers. The final stage of their service career was spent as tankers under the designation of KB-50K.

C/ns: 16465/16488
USAF serial numbers: 51-447/470

• B-50 TANKER CONVERSIONS – A total of 136 obsolescent B-50s were converted to hose tankers by Hayes Industries. This was a three-hose

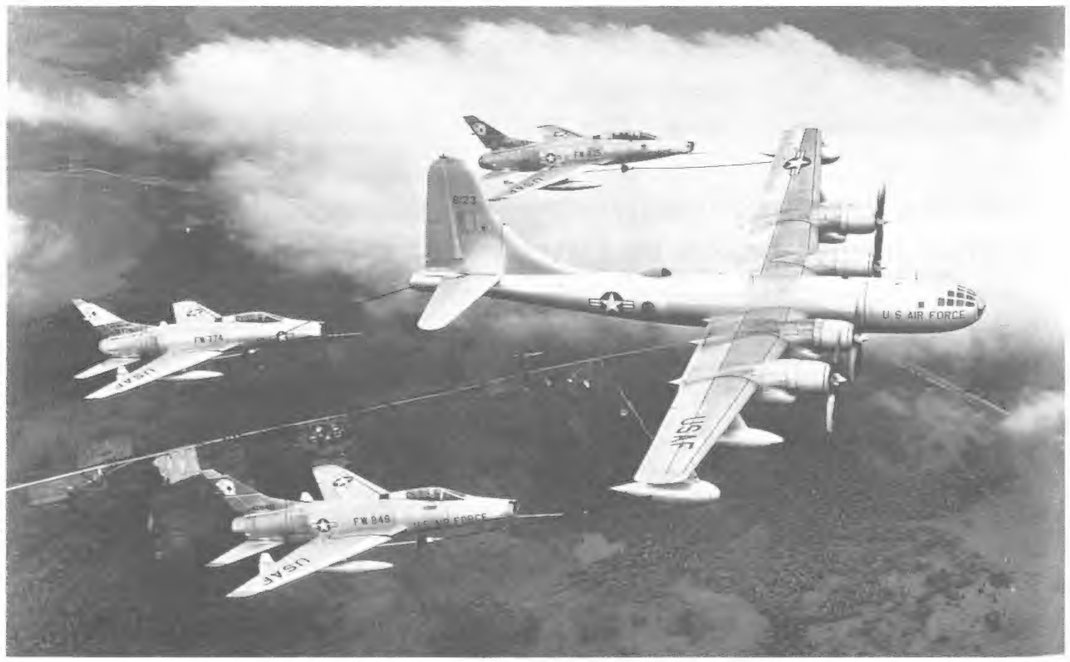
Obsolescent B-50s were converted to tankers; A through D to KB-50J shown, TB-50H to KB-50K. Note jet engine on former auxiliary fuel tank mounting. (*E M Sommerich Collection*)

arrangement, mainly for use of Tactical Air Command fighters which could refuel three at a time by the hose-and-probe method. One hose was unreeled from the tail, which was lengthened by six feet, and one each from a pod under each wing tip. The original B-50-type 700 gal auxiliary wing tanks were retained. No distinction was made at first between different series of B-50 aircraft that had been modified, and the tankers were identified only as KB-50. The structural and equipment differences soon made separation necessary for maintenance and operations, and distinguishing designations were applied.

When the KB-50s began to be phased out in 1964, their pumping equipment and jet pods were transferred to KC-97L tankers of the Air National Guard. A few KB-50s saw unexpected action in Vietnam in 1964 and 1965 when they were pressed into service to refuel jet fighters that were running low on fuel while still over communist territory. Some of these refuellings were accomplished at such low altitudes that they were under fire from the ground. The last KB-50s were retired in 1965.

• KB-50J – One hundred and twelve variously-modified B-50As and RB-50Bs that had been converted to KB-50 were designated KB-50J. To better match the faster jet receiver aircraft, two 5,200 lb thrust General Electric J-47 jet engines were installed at the former auxiliary wing tank locations. These increased the speed to 444 mph at 17,000 ft at a gross weight of 179,500 lb.

• KB-50K – All 24 TB-50H airframes, because of structural and equipment differences from earlier models, became known as KB-50K in their final tanker configuration but were otherwise identical to the KB-50Js.



KB-50J refuelling three North American F-100As simultaneously. (*Boeing Photo 160255*)

MODEL 367 (C-97 series) – The Model 367 was a cargo/transport design that grew out of the B-29 the same way that the Model 307 Stratoliner had developed from the B-17. Wings, tail, undercarriage, and power plant installations were identical. To obtain the needed cargo capacity, a double-lobe fuselage of two intersecting circular sections was developed. Two circular sections were preferable to a single ellipse of equivalent area to withstand stresses imposed by cabin pressurization. The cargo floor was built among the line of intersection. The lower lobe had the same diameter as the B-29 fuselage while the upper had a greater diameter and room for 134 fully-equipped troops, three loaded 1½ ton trucks, or two light tanks in its 74 ft length. Clamshell doors were fitted into the belly ahead of the tail and built-in ramps could be lowered to allow vehicles to be driven aboard. Bulk cargo was loaded by means of a hoist that ran on an overhead rail for the full length of the cabin. Two lower cargo holds ahead of and behind the wing could be loaded through outside doors.

While the C-97 series showed little change in outward appearance past the YC-97A version, Boeing developed many radically-improved versions on paper that incorporated advanced power plants and new wing and fuselage forms. No military support was obtained for these efforts, which finally culminated in the Model 367-80, which the company built at its own expense as the prototype American jet transport (see Chapter 13). Representative technical data for C-97s will be found on page 364.

MODEL 367-1-1 (XC-97) – Three prototypes were ordered in January 1942, and the first was flown on November 9, 1944. The second and third were identified by Boeing as Model 367-1-2. All three were used for test work and none saw wartime service. On January 9, 1945, the first set a transport-category speed record by covering the 3,323 miles from Seattle to Washington, D.C., nonstop in 6 hr 3 min with a 20,000 lb payload. Because

The third XC-97, showing double-lobe cargo fuselage on B-29 wing and tail. (*Boeing Photo X-1153*)

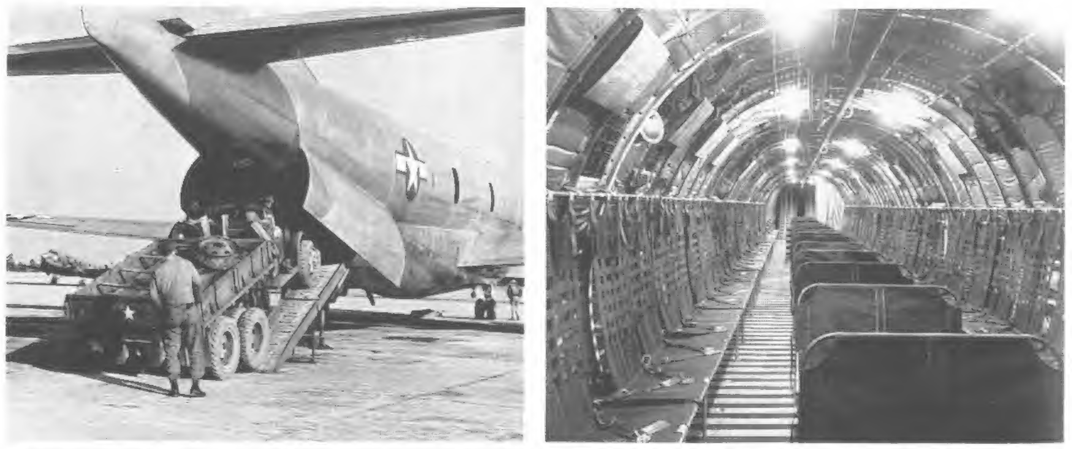
Third XC-97 with clamshell cargo doors open and loading ramp extended. (*Photo by Peter M Bowers*)

of its pressurized cabin, it could cruise at 30,000 ft, where it was able to take advantage of favourable winds for an average speed of 383 mph.

C/ns: 8481/8483
USAF serial numbers: 43-27470/27472

MODEL 367-5-5 (YC-97) - In July 1945, the Army ordered ten service test models of the C-97, six as YC-97, three as YC-97A, and one as YC-97B. The YC-97s were virtually identical to the XC-97s except for revised 'Andy Gump' engine nacelles developed for but not used on late B-29As, increased fuel capacity, and a higher-capacity electrical system. The first YC-97 flew on March 11, 1947, and all were soon put into Air Transport Command Service (ATC) from Fairfield-Susuin (later Travis AFB), California, to Hawaii. When the YC-97s were replaced by later models, at least one was obtained by a civil owner and used as a freighter under Restricted Type Certificate AR-23. Another became the property of Israel Aircraft Industries as payment for a maintenance bill.

C/ns: 15712/15717
USAF serial numbers: 45-59587/59592



Driving an Army truck up the ramp of an XC-97 (left) and (right) a view of the interior of a C-97A in troop carrier configuration. (*Boeing Photos 96084 and 108432*)

Cabin of a YC-97 arranged for medical evacuation. (*Boeing Photo P-10066*)

The spacious control cabin of the second Boeing XC-97 (*Boeing Photo 57016-B*)

The fourth YC-97 service test model of the XC-97. Note steps built into forward entry door. (*Photo by Peter M Bowers*)

MODEL 367-4-6 (YC-97A) – Although following the YC-97 in contract sequence and presented here for that reason, the YC-97A carried an earlier Boeing model number. It bore exactly the same relationship to the YC-97 that the B-50 bore to the B-29, namely the change to 75ST structure, P & W R-4360 engines, high tail, thermal de-icing, hydraulic rudder boost and nose wheel steering, folding vertical tail, and NESA glass heated windows for the pilots. An additional feature was a flight engineer's station in the control cabin. However, since there was no VJ cancellation of earlier versions, there was no need to change the designation as had been done with the B-29D/B-50A. The first YC-97A, which flew on January 28, 1948, remained at the factory for test work and support of Air Force business at Seattle until retired in January 1965. The third YC-97A achieved a degree of fame and thoroughly proved the C-97 design concept by intensive service on the Berlin Airlift of 1948, during which it carried such inefficient but essential cargoes as bulk coal, loaded by a conveyor belt.

All three were later modified up to production C-97A standard and redesignated C-97A. The third was later converted to C-97D.

C/ns: 15718/15720
USAF serial numbers: 45-59593/59595

The first YC-97A in C-97A configuration, shown in its sixteenth year of service. (*Boeing Photo P-39591*)

The YC-97B was structurally similar to the YC-97As except for luxury passenger accommodation and airliner-type windows. (*Photo by Gordon S Williams*)

MODEL 367-4-7 (YC-97B) – The tenth and last machine on the C-97 service test order was completed as a deluxe personnel transport under the designation of YC-97B. Structure, power plant, and equipment were similar to the YC-97A except for deletion of the cargo interior and clamshell loading doors. The main cabin had airline-type accommodation for 80 passengers, with separate men's and women's dressing rooms and a lounge compartment in the lower fuselage section aft of the wing. Chief outward recognition feature was the row of circular airliner-type windows. Following completion of service testing, the YC-97B was redesignated C-97B. In 1954, it was redesignated C-97D in company with one YC-97A and five converted C-97As.

C/ns: 15721
USAF serial number: 45-59596

MODEL 367-4-19 (C-97A) – A total of fifty C-97As were built, the initial order being for 27 production versions of the YC-97A costing $1,159,000 each. Seattle Plant 2 was occupied with B-50 and Stratocruiser construction, so part of the wartime Renton plant was reopened to establish a C-97 production line. Outwardly, the C-97A was distinguished from the YC-97A by the installation of a chin radome housing AN/APS-42 search radar. Fuel capacity was increased by additional outboard wing tanks to a total capacity of 7,790 gal and Hamilton Standard hydromatic propellers were used in place of the electrically-operated Curtiss models used on the YC-97As. A forward cargo door was installed at the starboard side of the upper cargo compartment from the 28th C-97A onward, and all were fitted with an aerial delivery system whereby 25,500 lb of cargo suspended from the overhead rail could be parachuted out of the clamshell doors in 15 sec. In addition, two 3- or 4-blade propellers, too large for the cabin, could be carried on external mountings under the forward fuselage. Block numbers were -1 to -30. Two C-97As were converted to C-97D, three to VC-97D (which see), and three became KC-97A.

C/ns: 16009/16035 16211/16233
USAF serial numbers: 48-397/423, 49-2589/2611

C-97A was first production Stratofreighter, distinguishable from YC-97As by addition of 'chin' radome. Third example shown in MATS markings. (*Boeing Photo P-9466*)

• JC-97A – One C-97A, 48-397, was temporarily designated JC-97A when used for test work.

• KC-97A – Three standard C-97As (49-2591, 2592, 2596) were fitted with an improved version of the Boeing Flying Boom developed on the KB-29P to test the suitability of the C-97 as a tanker. The KB-29s were not well-matched to the more powerful B-50s then in service and could not be expected to refuel the jet bombers that were soon to enter service. Where the boom had been attached to the tail of the KB-29 and was operated from the former tail gunner's station, the location was more forward on the KC-97A. The clamshell cargo doors were removed and a pod was installed for the operator, who lay prone, and the boom was attached immediately behind the pod. The C-97A proved eminently suitable for the job, but the three test aeroplanes, which had not been designed specifically for it, were reconverted to standard C-97As, one becoming VC-97D.

MODEL 367-4-29 (C-97C, KC-97E) – Relatively minor changes in the instrumentation, different radio equipment, and a reinforced cargo floor resulted in a designation change to C-97C. Fourteen were built, principally for air evacuation use, with delivery being completed in 1951.

The C-97Cs followed the B-50 practice of continuing the block numbers from one series into the next. All C-97Cs were built as C-97C-35, continuing from C-97A-30 since there were no production C-97Bs.

C/ns: 16234/16247
USAF serial numbers: 50-690/703

• MC-97C – The prefix M was applied to the designations of C-97Cs used for medical evacuation during the Korean War of 1950–53.

• KC-97E – The sixty KC-97Es incorporated the same mechanical and structural changes as the C-97C, but were initially fitted as tankers with the

improved flying boom developed on the KC-97A. This, coupled with the installation of four additional fuel tanks totalling 7,200 gal installed on the upper cargo floor, justified the military designation change. Improved P & W R-4360-35C engines replaced the 35A models that had been standard on all C-97s from the YC-97A. While used primarily as tankers, the IFR pod could be removed and replaced with cargo doors and the upper deck fuel tanks could be removed. KC-97E block numbers were -40 to -50.

C/ns: 16250/16309
USAF serial numbers: 51-183/242

MODEL 367-76-29 (KC-97F, KC-97G) – Only two models, the KC-97F and KC-97G, were built under this designation, all subsequent designations being conversions.

KC-97F, representative of production KC-97Es and Gs, featured entirely different flying boom installation than used on KB-29Ps. (*Boeing-Wichita Photo BW-92595*)

• KC-97F – The changes in the 159 KC-97Fs were mainly in the power plants and their instrumentation, the R-4360-59B engines being installed and equipped with engine analysers. KC-97F block numbers were -50 to -85. When the refuelling equipment was removed the KC-97F aeroplanes became plain C-97F.

C/ns: 16310/16464, 16489, 16490, 16504, 16505
USAF serial numbers: 51-243/397, 51-7256/7259

• KC-97G – The KC-97G used the same engines as the KC-97F and the same factory model number. Minor changes were made, however, to permit operation as a transport without the need to remove the IFR system tanks from the main cabin. This gave the KC-97G greater utility and it became the major production version of the series, a total of 592 having been built at an average cost of $1,205,000 before the KC-135A jet tanker replaced it on the Renton production line in 1956. A minor change was deletion of the established radio operator's station as a result of adopting much automatically controlled equipment. KC-97G block numbers were -90 to -140, and the principal recognition feature was the addition of 700 gal B-50D auxiliary fuel tanks.

C/ns	*USAF serial numbers*
16506/16517	51-7260/7271
16520/16632	52-826/938
16633/16837	52-2602/2806
16888/17147	53-106/365
17148,17149	53-3815, 3816

• C-97G – In 1963 and 1964, 135 KC-97Gs that had been turned over to the National Guard Air Units were modified to plain C-97G in cargo configuration by removal of the in-flight refuelling (IFR) systems.
Serial numbers 51-7269, 52-827/832, 835/838, 840, 843, 857/859, 862, 871, 873, 874, 876/878, 885, 886, 888, 890, 894, 897/899, 908, 911, 915, 917, 921/932, 934/938, 2602, 2607, 2608, 2610/2612, 2616, 2620, 2621, 2626, 2631/2635, 2641, 2643, 2646/2650, 2652, 2655, 2660, 2661, 2663, 2667, 2673, 2674, 2676, 2678, 2679, 2682, 2683, 2686/2691, 2696, 2717, 2719/2729, 2732/2736, 2759, 2764, 2766, 2768, 2795, 2799, 2805, 53-106, 119, 138, 140, 142, 145, 160, 162, 197, 201, 209/215, 217, 220, 228, 233/236, 238/240, 242, 261, 270/275, 279, 284, 294, 297, 306, 311/314, 316, 324, 329, 330, 332, 334, 335, 337/342, 346, 349, 353, 356, 358, 359, 364, 365, 3815.

EC-97G 52-2639 photographed in May 1968. (*Norman Taylor Collection*)

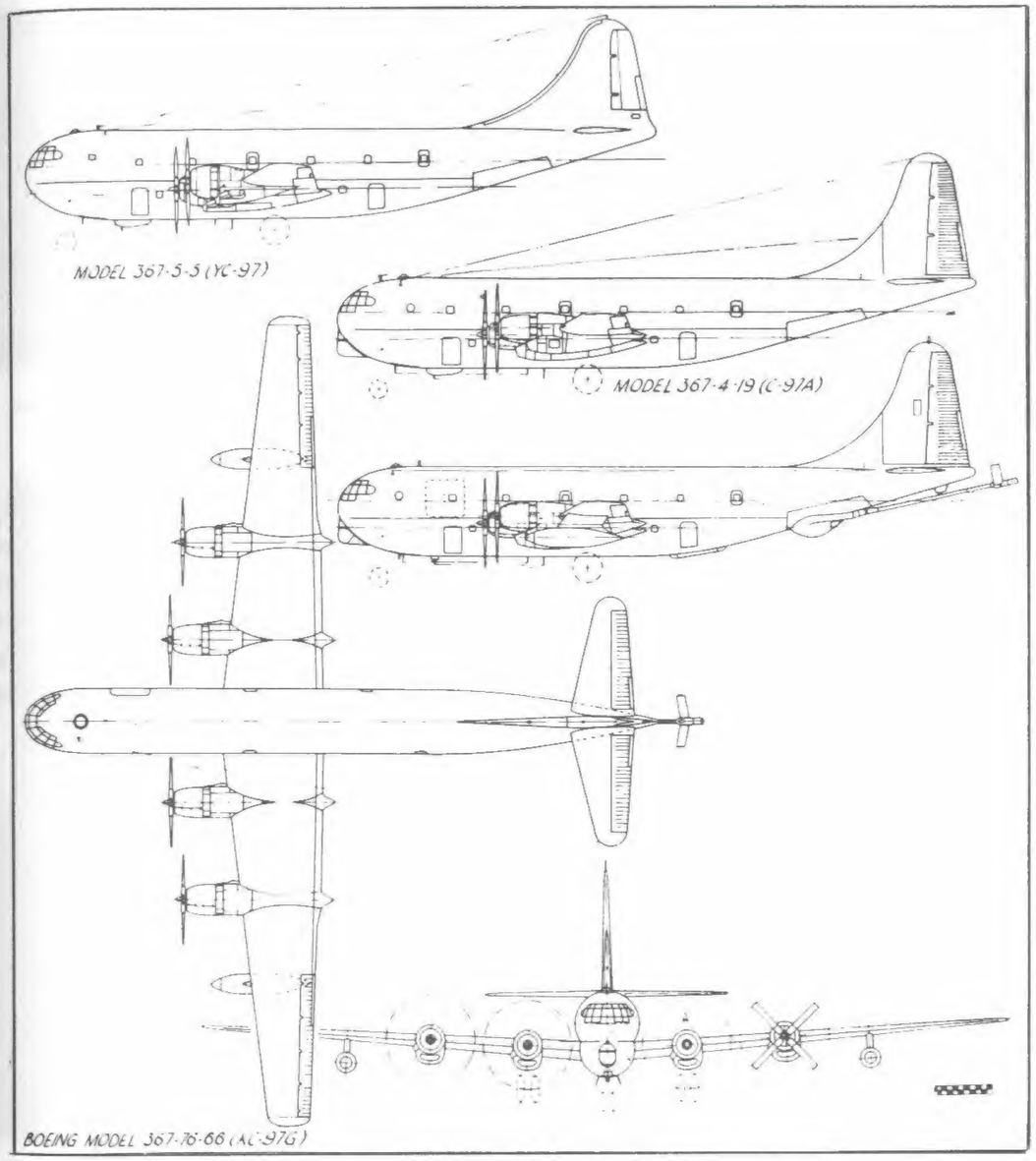
• EC-97G – Three C-97Gs (52-2724, 53-106, 220) modified for testing of electronic equipment.

• HC-97G – At least 29 KC-97Gs were converted to Search and Rescue configuration by the Fairchild-Stratos Corporation.
Known serial numbers: 52-916, 2617, 2618, 2651, 2665, 2713, 2714, 2716, 2739, 2754, 2773, 2782, 2783, 2791, 2797, 2806, 53-115, 117, 120, 122, 131, 134, 147, 161, 165, 170, 173, 174, 216.

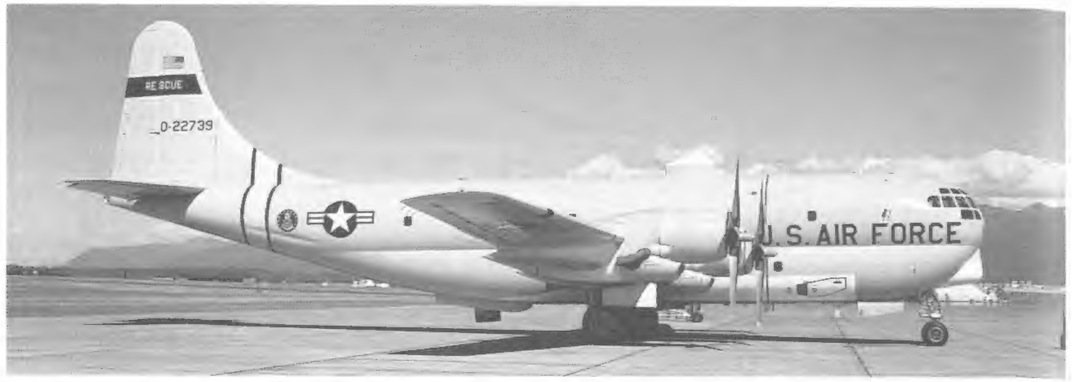
CONVERTED C-97s

The C-97D series and all C-97 designations above KC-97G were converted aircraft as detailed below:

• C-97D – The third YC-97A (45-59595), the YC-97B (45-59596), and two C-97As (48-411, 415) were modified to straight passenger configuration and redesignated C-97D. The three VC-97Ds were also reclassified as C-97D.



Distinguishing feature of the KC-97G was addition of 700 gal wing tanks. (*Boeing Photo P 17599*)



Boeing HC-97H, formerly HC-97G-135, with glossy light grey finish and black and yellow air-sea rescue markings. (*Photo by Norman Taylor*)

• VC-97D – Three C-97A airframes (*USAF serials* 49-2593, 2594, 2596) were modified by Boeing through deletion of the cargo doors, the installation of provisions for 700-gal B-50D-type auxiliary fuel tanks under the wings, and the installation of Stratocruiser-type passenger entry doors on the port side of the upper deck. Interior installations were completed by a specialized contractor to fit the three aircraft as flying command posts for Strategic Air Command personnel, including office and living quarters.

The third YC-97A was redesignated C-97D. (*Photo by Peter M Bowers*)

• KC-97H – One KC-97F (51-322) was modified in 1953 for trial as a hose tanker using the probe-and-drogue system for refuelling fighters and some of the smaller bombers. While not adopted for the C-97 tankers, this system was later used with three hoses on the KB-50s.

• YC-97J – In 1955, two KC-97Gs (52-2693, 2762) were modified at Air Force request to serve as flying test beds in which to accumulate service experience with the 5,700 hp P & W YT34-P-5 turboprop engine. This request was a bit ironic for Boeing, coming as it did practically at the end of C-97 production and long after Boeing had tried to interest the Air Force in turbine power as a means of greatly improving the basic C-97 design. As it was, the lighter weight and greater power of the turboprops greatly increased the performance of the YC-97J, which received the factory

The single KC-97H refuels a Douglas RB-66B by the hose-and-drogue technique. (*USAF Photo SM-201595*)

The two YC-97Js were KC-97Gs fitted with 5,500 hp propeller-turbines. (*Boeing Photo P15262*)

KC-97Ls were Air National Guard KC-97Gs fitted with auxiliary J47 jet engines. (*Photo by Norman Taylor*)

designation of 367-86-542, over that of the standard model. The original designation assigned to the modified aeroplanes was YC-97H, but since the power plant change resulted in practically a new design, the designation of YC-137 was tentatively assigned to reflect the more modern features. By the time this was rejected, the H series letter had been assigned to another C-97 variant so the turboprop versions became YC-97J. Structural modifications and the new engines raised the cost of the YC-97J to $2,106,542.

• C-97K – Twenty-seven KC-97Gs were modified to passenger configuration for support of MATS missions by deletion of all tanker features but the boom operator's pod. The cargo doors were closed off and the main cabin was fitted with permanent pasenger seats of the type used in Douglas C-54 aircraft.
USAF serial numbers: 52-2606, 2609, 2613, 2614, 2623/2625, 2627, 2628, 2645, 2653, 2657, 2658, 2662, 2669, 2671, 2672, 2681, 2684, 2699, 2730, 2731, 2790, 53-163, 182, 343, 344.

• KC-97L – In 1964, some of the KC-97G aircraft that had been assigned to the Air National Guard were given improved compatibility with jet fighters by the installation of J47 jet engines on the former auxiliary wing tank mounts in the manner of KB-50s. The last KC-97Ls were retired in 1977.

TECHNICAL DATA – C-97 SERIES

	YC-97	*KC-9G*	*YC-97J*
Accommodation:	5 crew; 134 troops or 83 stretcher patients and 4 attendants	4 crew; 96 troops or 69 stretcher cases, plus tanker equipment	4 crew (cargo configuration)
Power plant:	Wright R-3350-57A 2,325 hp	P & W R-4360-59B 3,500 hp	P & W YT-34P-5 5,700 hp
Span:	141 ft 3 in	141 ft 3 in	141 ft 3 in
Length:	110 ft 4 in	117 ft 5 in (incl boom)	110 ft 4 in
Height:	33 ft 3 in	38 ft 3 in	38 ft 3 in
Wing area:	1,738 sq ft	1,769 sq ft	1,768 sq ft
Empty weight:	69,793 lb	82,500 lb	72,188 lb
Gross weight:	120,000 lb	175,000 lb	175,000 lb
Max speed:	346 mph at 25,000 ft	375 mph	417 mph at 25,500 ft
Climb:	15,000 ft in 30 min	20,000 ft in 50 min	20,000 ft in 14·4 min
Operating ceiling:	28,700 ft	30,200 ft	35,000 ft
Range:	3,100 miles	4,300 miles	2,300 miles

SURPLUS C-97 ACTIVITY

As C-97s became surplus to the needs of the USAF they were made available on the surplus market. The YC-97s received Restricted Type Certificate AR-23 on April 9, 1957, while the C/KC-97s received four

Silver-painted surplus YC-97 fitted with underwing spray booms in 1957 to combat an infestation of gipsy moths in New York State. Note USAF in-service addition of a C-97A nose radar pod. (*Photo by Milo Peltzer*)

separate examples of the later form of certificate that was numbered according to the FAA region in which it was issued. These were issued to the individual firms that developed and installed special equipment of their own design to suit the C-97s as spraying aircraft or tankers in the manner of the B-17, not to Boeing. At April 1988 there were four C-97Gs, 13 KC-97Gs, and six KC-97Ls registered in the United States, mostly to tanker operators.

There were also some foreign sales, with eight KC-97Gs and one KC-97F going to Israel. Although carrying civil registrations, these aircraft were in the Israeli Air Force and incorporated military modifications that included, in some cases, two underwing pods for hose-and-drogue refuelling of fighters.

MODEL 377 (STRATOCRUISER series) – The 377 series was a commercial development of the military C-97 (Boeing Model 367) series, and used the 75ST structure and P & W four-row engines of the YC-97A and on. Named Stratocruiser by Boeing, the postwar airliner had passenger accommodation, window arrangement, and entry doors similar to those of the YC-97B. Depending on seating density and arrangement, the main passenger cabin could seat from 55 to 100 passengers. When equipped as a sleeper aircraft the 377 contained 28 upper and lower berth units plus five seats. A spiral staircase led to a lounge on the lower deck behind the wing that could hold an additional 14 passengers. This was generally used as a luxury bar by the airlines and seating space in it was not sold or used to increase overall capacity. Complete dressing rooms were provided for both men and women, and the most complete galley provided to that time in a commercial airliner was installed at the rear of the cabin. The number of cabin attendants varied, but the flight crew consisted of pilot, co-pilot, navigator, engineer, and radio operator.

Before the first Stratocruiser was completed, Boeing released artists' drawings made from XC-97 photos to publicize the new airliner. This paper aeroplane carried the fictional registration NC47377, which identified it as the 1947 Model 377 much in the manner that Stratoliner NX19906 had been renumbered NX1940 to publicize The 1940 Airliner.

The first Model 377-10-26 Stratocruiser for PAA in Boeing prototype markings. (*Boeing Photo P-8203*)

Although the 377s delivered to six customer airlines were structurally the same and carried the same ATC 812, they differed considerably in interior appointments. This caused Boeing to assign a variation of the basic model number to each airline, a practice that was to continue into jet transport production. All Stratocruisers were delivered between February 1949, and March 1950, at a price of approximately $1,500,000 per aeroplane.

• 377-10-19 – The prototype Stratocruiser was known to factory personnel as No. 11 because it followed the 10th plane of the YC-97 contract (YC-97B) on the production line. The first commercial model was a Boeing-owned aeroplane used for most of the testing toward certification of the 377

Main cabin of 377-10-28 SAS/BOAC Stratocruiser. (*Boeing Photo 111178*)

series under ATC 812. The fact that it was called 'Dog Ship' was no reflection on its characteristics. The expression is a long-established flight test term, going back almost to WW-I, used to designate a prototype or developmental model that undergoes all the experimental changes, carries the test equipment in a stripped interior, and generally gets kicked around. First flight of the 377-10-19 was on July 8, 1947. It was bought in stripped condition by Pan American Airways after that line had received all of its 377-10-26s, and was modified up to -26 standard in the airline shops and given a new registration number.

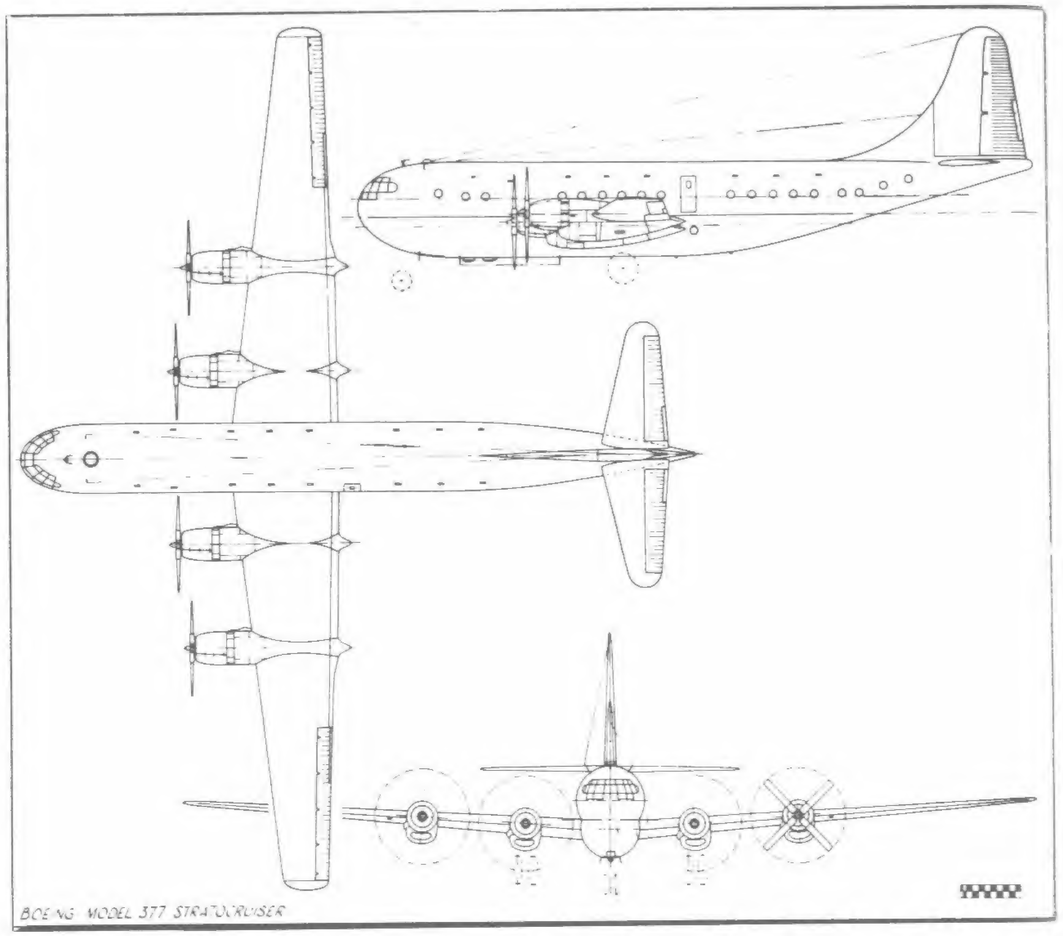
TECHNICAL DATA – MODEL 377 STRATOCRUISER

Type:	Long-range transport
Accommodation:	55–100 passengers and attendants, 5 flight crew
Power plant:	Four P & W R-4360 Double Wasp, 3,500 hp for take-off
Span:	141 ft 3 in
Length:	110 ft 4 in
Height:	38 ft 3 in (26 ft 7 in with fin folded)
Wing area:	1,720 sq ft
Empty weight:	78,920 lb
Gross weight:	135,000 lb (later 148,000 lb)
High speed:	375 mph
Cruising speed:	340 mph at 1,900 hp per engine at 25,000 ft
Initial climb:	1,040 ft/min
Service ceiling:	32,000 ft
Range:	4,200 miles with maximum fuel
C/n:	15922
Registration:	NX-90700, later N1022V (377-10-19 to 377-10-26)

• 377-10-26 – Pan American World Airways placed the original and the largest order for Stratocruisers, 20 of the 55 built. One PAA Stratocruiser, NX1039V, was flown originally in Boeing markings and used as a second prototype in the certification programme. The airline bought the factory-owned 377-10-19 prototype and modified it to 377-10-26, then obtained the six American Overseas 377-10-20s by merger for a fleet total of 29 before selling one 377-10-26 to BOAC. Ten -26s used by PAA's Atlantic Division were modified to Super Stratocruisers by installation of tanks for an additional 450 gal of fuel to permit nonstop flights from New York to London or Paris. Original fuel capacity was 7,790 gal. All 29 were later fitted with new turbo-superchargers that produced an additional 50 hp per engine. Most of the PAA Stratocruisers became Boeing property in 1958–59 when they were traded in for new Model 707 jet transports.

C/ns:	15923/15942
Registrations:	NC1023V/1042V (1027V to G-ANUM *Clyde*)

• 377-10-28 – Four Stratocruisers were ordered by the combined Swedish, Norwegian, and Danish airlines now known as Scandinavian Airlines



System or SAS. Two were given Swedish registration and one each Norwegian and Danish. Interior appointments were extra deluxe and were different for each aeroplane. All were acquired by BOAC before flying under SAS colours and three were sold in 1958 to Transocean Airlines, which had its headquarters in Oakland, California.

C/ns		*Registrations*	
15943	SE-BDP	G-ALSA *Cathay*	
15944	OY-DFY	G-ALSB *Champion*	N103Q
15945	LN-LAF	G-ALSC *Centaurus*	N101Q
15946	SE-BDR	G-ALSD *Cassiopeia*	N86Q

• 377-10-29 – Eight Stratocruisers were ordered by American Overseas Airlines (AOA), the transatlantic subsidary of American Airlines (AA). Although flown in AOA markings, these machines were taken over by PAA when AOA was merged with PAA.

C/ns: 15957/15964 *Registrations:* NC90941/90948

• 377-10-30 – Northwest Airlines (NWA) took delivery of ten Stratocruisers that differed in outward appearance from the others in that the windows were rectangular instead of circular. After a period of service, the airline changed the appearance still more by adding a C-97A-type weather radome to the nose.

Looking forward in cabin of a Boeing 377 as the flight attendant lowers the rearmost upper berth after those ahead have already been made up. (*Boeing Photo P-8127*)

Looking aft on the main deck of a Stratocruiser, with the stairs to the lower deck in the right foreground. This example has the square cabin windows as used by Northwest Airlines and United Air Lines. (*Boeing Photo P8987*)

Northwest Airlines 377-10-30 fitted with a C-97A-type 'chin' radome. (*Photo by Logan Coombs*)

After nearly ten years of service, these aircraft were traded-in to Lockheed Aircraft Corp for new turboprop Lockheed Electras and Lockheed disposed of some of them to Aero Space Lines for eventual conversion to 377-PG.

C/ns: 15947/15956
Registrations: NC74601/74610

• 377-10-32 – Only the first six of what was eventually to become a 17-Stratocruiser fleet for BOAC were ordered from the factory, all others being taken over from other airlines. The original six and four others were sold to Transocean Airlines of Oakland, California, in 1958 to make way for newer jet transports.

C/ns:	*Registrations*	
15974	G-AKGH *Caledonia*	N137A, 402Q
15975	G-AKGI *Caribou*	N100Q, 405Q
15976	G-AKGJ *Cambria*	N102Q, 407Q
15977	G-AKGK *Canopus*	N105Q, 409Q
15978	G-AKGL *Cabot*	N85Q, 404Q
15979	G-AKGM *Castor*	N104Q, 410Q

• 377-10-34 – United Air Lines (UAL) ordered seven Stratocruisers with rectangular windows similar to the NWA 377-10-30s, and used them for service to Hawaii and within the continental United States, the only airline to do so. After relatively short service, six were sold to BOAC.

C/ns		*Registrations*	
15965	NC31225	G-ANTX *Cleopatra*	107Q, N412Q
15966	NC31226	G-ANTY *Coriolanus*	108Q, N413Q
15967	NC31227	G-ANTZ *Cordelia*	106Q, N411Q
15968	NC31228	G-ANUA *Cameronian*	109Q, N414Q
15969	NC31229	G-ANUB *Calypso*	
15970	NC31230		
15971	NC31231	*G-ANUC Clio*	

STRATOCRUISER MODIFICATIONS

Following nearly ten years of first-class service with BOAC, ten 377s of various configurations were obtained by Transocean, which conducted a large charter and contract passenger operation. Four 377s were modified to high-density tourist configuration with 117 seats, and 12 seats were added to the 63 and 84 seat arrangements of the remaining six.

• 377 Cargo Conversion – Six of the surplus airline 377s were obtained by Rutas Aereas Nacionales SA (RANSA) of Venezuela for conversion to cargo configuration. This consisted of the installation of C-97 type cargo doors.

Of five Model 377s acquired by the Israeli Air Force but flown in civil markings, two were modified by Israel Aircraft Industries to have 'swing tail' rear loading, in which the entire fuselage and tail aft of the wing swung to the right. This modification was not worth the cost, so the other three Model 377s were modified to use C-97 type clamshell loading doors and ramps, plus upper-deck side cargo doors.

• 377-PG – This is probably one of the most unusual aeroplane modifications in history. The second PAA 377-10-26 (N1024V) was acquired by Aero Space Lines Corp, which had the On-Mark Engineering Co of Van Nuys, California, alter it for aerial transportation of large spacecraft sections from West Coast manufacturing plants to the test site at Cape Canaveral (now Kennedy) in Florida. Too large to be transported by rail or truck, these giant sections could be delivered only by sea, a hazardous, time-consuming, and costly operation. The Stratocruiser, already a large-capacity machine and available for very low prices at the time, was the logical choice for the job. The modification was accomplished in three phases after wind tunnel testing at Boeing proved the conversion to be aerodynamically feasible.

First, the aeroplane was lengthed 16 ft 8 in by splicing in, just aft of the wing, a straight fuselage section from another Stratocruiser. Next, to check the aerodynamic effects of the proposed cabin enlargement, a super-structure was built around the upper fuselage to simulate the final contours. This gave a very distorted appearance to the machine, which was christened, rather facetiously, the Pregnant Guppy. The initials PG were then made part of the official designation. When the new shape proved to have no

One of the world's most extreme aeroplane modifications – the Model 377-PG (*Courtesy Hal Loomis*)

adverse aerodynamic effect, the original roof structure was cut out and the 20 ft high cargo area was completed. Loading was accomplished by another radical innovation – the entire fuselage aft of the wing was unbolted from the rest of the aeroplane and rolled backward on a special carriage so that the cargo, usually a Saturn IV unit, could be loaded by a special elevating carriage.

In May 1963, a supplemental Type Certificate was issued under Part 8 of the Civil Air Regulations for a maximum payload of 34,000 lb. In spite of the additional structure, empty weight increased to only 91,000 lb. Cruising speed, not important on this mission, was reduced to 250 mph.

PRODUCTION GUPPIES

The success of the 377-PG inspired the production of eight more. The second, called Super Guppy, or 377-SG, was larger, and used many components, particularly the 5,700 hp P & W T-43-PWA propeller-turbine power packages, wing, and forward fuselage section of YC-97J 52-2693. Parts of four Stratocruisers were also used. The 377-SG was fitted with a new centre section that added 15 ft to the wingspan and had a fuselage 31 ft longer than a standard Model 377. Cargo up to 25 ft in diameter could be loaded through a hinged nose. The nose landing gear was de-rigged to swivel 90 degrees to port, jacks were lowered under the forward fuselage, and the whole nose opened horizontally, rolling on the nosewheels.

The 377-SG was followed by a smaller Mini Guppy, 377-MG, that was built in a new location at Santa Barbara, California, and again used its former Stratocruiser c/n and registration. This largely duplicated the original 377-PG except for having the tail swing open to starboard instead of removing the entire rear fuselage to facilitate loading. Two more Mini Guppies, now designated Model 101 and featuring 4,680 hp Allison propeller-turbine power packages from surplus Navy Lockheed P-3A Orion patrol aircraft, plus new c/ns and registrations, were built in Santa Barbara. These re-adopted the swing nose for loading.

Two 'production' versions of the 377-SG were then built at Santa Barbara as Model 201, again with Allison engines and new c/ns. While these still used many Stratocruiser components, some were now from surplus C-97s,

The first Mini Guppy, rebuilt from Stratocruiser 377-10-26 N1037V. Note external hinges for swing tail. (*Photo by Kenneth M Sumney*)

Fuselage section of an Airbus A300 wide-body jetliner stowed inside the fuselage of a Super Guppy 201. (*Photo by Alain Pelletier*)

which had much lower flight times than the well-worn Stratocruisers. Both of the Model 201s were sold to Airbus Industrie in France.

This purchase was ironic in a way. Airbus has been Boeing's principal competitor in the jet transport business since the early 1970s and uses its Super Guppy fleet to airlift major Airbus components from widely separated plants in serveral European countries to Toulouse for final assembly. While the Super Guppies are not built by Boeing, they use Boeing-built components so, indirectly, Boeing products are indispensable to Airbus production.

Airbus wanted an additional two Super Guppies, but Aero Spacelines was not in a position to build them. Arrangements were then made for Union de Transports Aériens (UTA) to build them in its plant near Paris, using Stratocruiser and C-97 components supplied by Aero Spacelines.

A complete list of the nine Guppies is given below, followed by specifications and performance of the Model 201 Super Guppy.

F-BTGV Model 201 Super Guppy with nose swung open to port. (*Alain Collection*)

Model	*Registration*	*C/n*	*Power plant*	*First flight*
377-PG Pregnant Guppy	N1024V	15925	P & W R-4360	Sept 16, 1962
377-SG Super Guppy	N1038V	15938	P & W YT-34-P	Aug 31, 1965
377-MG Mini Guppy	N1037V (1)	15937	P & W R-4360	May 24, 1967
Model 101 Mini Guppy	N111AS	0001	Allison 501	May 1, 1970
Model 101 Mini Guppy	N112AS	0002	Allison 501	-
Model 201 Super Guppy	N211AS (2)	0001	Allison 501	Aug 6, 1970
Model 201 Super Guppy	N212AS (3)	0002	Allison 501	May 6, 1973
Model 201 Super Guppy	F-WDSG (4)	0003	Allison 501	June 1, 1982
Model 201 Super Guppy	F-WEAI (5)	0004	Allison 501	June 21, 1983

(1) to N422AU
(2) to F-BTGV
(3) to F-BPPA
(4) to F-BDSG
(5) to F-GEAI

TECHNICAL DATA - MODEL 201 SUPER GUPPY

Type: Converted airliner for specialized oversize cargo
Power plant: Allison 501-D22C, 4,680 ehp
Span: 156 ft 8 in
Length: 143 ft 10 in
Height: 48 ft 3 in
Empty weight: 101, 075 lb
Gross weight: 170,000 lb
Cruising speed: 290 mph
Range (ferry): 2,000 miles

MODEL 451 (XL-15, YL-15) - Named the Scout, this two-seat Army liaison aircraft was entirely a Wichita Division development originally identified as Wichita Model 200 although a Seattle model number was actually used. The old Stearman-type serial number system was retained. The Scout was a rather extreme departure from the established liaison types, most of which had been standard commerical lightplanes adapted to military requirements. An all-out effort was made to achieve maximum visibility for the observer and good flight control at extremely low speeds. Increased utility for the ground forces who were to operate it was sought through quick-dismantling features so that the machine could be ground-transported on a standard army truck. To decrease the folded width for trailering on its own wheels or for stowage in a C-97, the landing gear struts could be rotated inward about their vertical axes to put the wheels on the inside of the struts. Twin floats or skis could be fitted as alternate equipment. Other than the single boom supporting the double tail, the outstanding aerodynamic feature was the use of 'flaperons' that were separated from the basic wing structure and operated over a range of 10 degrees up to 40 degrees down. They also operated as ailerons in conjunction with the differentially-operated spoilers that also served the aileron function.

• XL-15 - The design for the XL-15 was initiated in July 1946, and the first

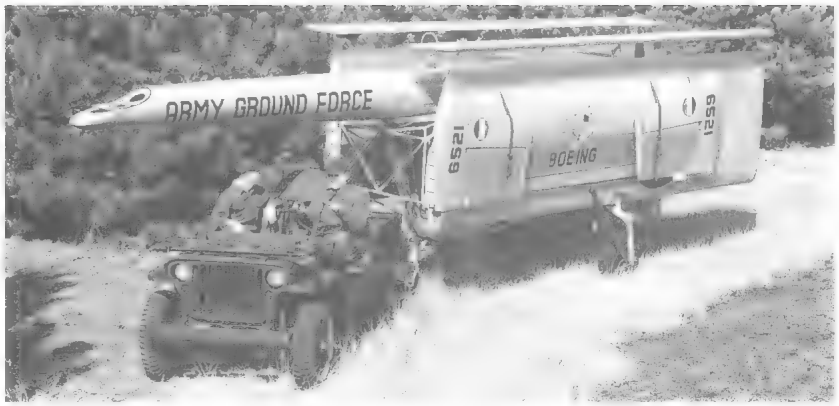
The unique Boeing Model 451, the XL-15 Scout, in flight. Note separate 'flaperons'. (*Boeing Photo 2B-3427*)

flight was made on July 13, 1947. Construction was all metal except for fabric covering on movable control surfaces.

TECHNICAL DATA - XL-15 SCOUT

Type: Liaison-observation
Accommodation: 1 pilot, 1 observer
Power plant: Lycoming 0-290-7, 125 hp
Span: 40 ft
Length: 25 ft 3 in
Height: 8 ft 8½ in
Wing area: 269 sq ft
Empty weight: 1,509 lb
Gross weight: 2,050 lb
Max speed: 112 mph
Cruising speed: 101 mph
Stalling speed: 35 mph

The second XL-15 fitted as a seaplane. (*Boeing-Wichita Photo P-7687*)



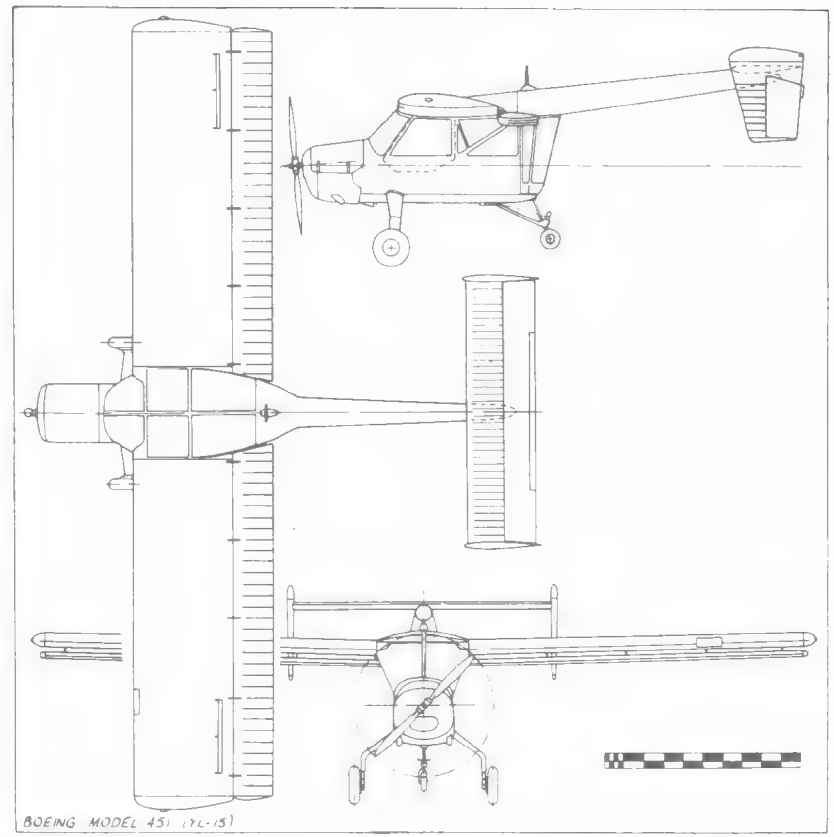
XL-15 could be dismantled and converted to self-contained trailer for towing on its own wheels at speeds up to 40 mph. (*Boeing-Wichita Photo BW-37639*)

Climb:	628 ft/min
Service ceiling:	16,400 ft
Endurance:	2¼ hr normal, 5½ hr with auxiliary fuel
Armament:	None
C/ns:	20001, 20002
Army serial numbers:	46-520, 521

• YL-15 - Ten YL-15s were built in 1948-49 as service versions of the two XL-15 prototypes and were identical in performance and in appearance except for a slight enlargement of the rudders. After service test, the Army turned the YL-15s over the US Forest Service and the Department of the Interior, which operated them under civil registrations and eventually disposed of some to private owners.

C/ns:	20003/20012
Army serial numbers:	47-423/432

The ten service-test YL-15s were outwardly identical to the two XL-15s (*Photo by Peter M Bowers*)



Chapter 11

JET BOMBERS

The Jet Age began in the greatest secrecy on August 27, 1939, when the German Heinkel He 178 research aircraft, powered with a 1,100 lb thrust Heinkel He 53 gas-turbine, or jet engine, made its first flight. This new form of propulsion met stubborn resistance on the part of German officialdom and, fortunately for the Allies, the operational debut of the jet fighter was delayed for nearly three years. Even then (again fortunately) it was grossly mismanaged. In the meantime, an entirely independent research programme was being conducted in England, where the first British jet, the Gloster E28/39, made its first flight on May 14, 1941.

As soon as the merits of this new type of power plant were acknowledged by the Royal Air Force, jet fighters were designed and put into production and samples of the new engines were rushed to the United States so that American industry could also develop jet aircraft for the war effort. However, because of the small size and power of the original jet engines, only jet fighters saw action by war's end, at least on the Allied side, and even then on a very small scale. The jets developed rapidly, however, and propeller-driven fighters remained in production for only a short time after the war. The significant military beginning of the Jet Age can be said to coincide with the demise of the propeller-driven fighter in the 1946–48 period. Jet bombers were operational in the US Air Force by 1950 and saw action in the Korean War. This conflict, from 1950 to 1952, saw the first all-jet engagements between opposing air forces and serves as the most convenient milestone by which to date the coming of age of the military jet and its complete displacement of piston-engine aircraft from the inventory of first line combat equipment.

Boeing research in jet bomber design began late in 1943 at government request. After many trial configurations, plus the use of German research data that became available at war's end, Boeing built two prototype jet bombers known as the B-47 (Boeing Model 450 Stratojet) that were to be evaluated against prototypes built by other manufacturers. The XB-47s were extremely daring in concept, almost to the point of being radical. The forward step taken by this design was far greater than those taken either by the Model 214/B-9 or the Model 299/B-17. The B-47 not only exceeded the performance of its more conventional contemporaries but it became the predominant Air Force bomber in its class and established the world pattern for jet bombers and transports that was to prevail for the next two decades. So great was the demand for B-47s at the time of the Korean war that the

Boeing enters the Jet Age – roll-out of the first XB-47 on September 12, 1947. Expansion of Plant 2 over 11 years is emphasized by fact that the low element of the building directly aft of the aeroplane is the original Plant 2 unit shown on page 195. (*Boeing Photo P-7423*)

WW-II B.V.D. pool was re-established. Douglas built 274 B-47s at Tulsa, Oklahoma, and Lockheed built 385 in the former Bell B-29 plant at Marietta, Georgia. The basic design of the B-47 was used in another Boeing jet bomber, the B-52 (Boeing Model 464 Stratofortress), which was likewise developed in competition with another manufacturer and won out to become the only production model in its class.

Since only the two XB-47 prototypes had been built in Seattle soon after WW-II, jet noise did not become a significant community relations problem at that time. When B-52 production got under way in 1953, the problem became acute. Curfews were established for the running of jet engines in the test aircraft at the new Flight Test Centre that had been built on Boeing Field in 1951 and a new Jet Delivery Centre was established at Larson Air Force Base in the Central Washington desert near Moses Lake, situated east of the Cascade Mountains and nearly 150 air miles from Seattle. The production B-52s made their first flights from Boeing Field with reduced loads and landed at Larson. Here the big jet bombers could be given their shakedown tests and their engines could be run at all hours as necessary to meet military delivery schedules. Most of the Seattle-built B-52s and the later KC-135s were delivered to the Air Force from this facility until it was closed as an economy measure.

The early postwar years also saw the birth of the missile age. Air-to-air rockets had been carried by fighter and attack aircraft in the later years of WW-II to increase their firepower beyond the capabilities of the traditional machine guns and 20 mm and 37 mm light cannon. Ground-to-air interceptor rockets were also under development and Boeing entered the field in 1947 with an Army-funded interceptor missile known as GAPA, the word being an acronym for Ground-to-Air Pilotless Aircraft. GAPA work

led to development of the BOMARC, a rocket-ramjet-powered interceptor missile that was first launched in 1952 and remained in large-scale production until 1962. The name was derived from the names of the two developing organizations, Boeing and the Michigan Aeronautical Research Centre. The Air Force officially regarded missiles of this type as aircraft even though they were without human pilots, and assigned the standard fighter designation of F-99 to the Bomarc. However, the tremendous differences between the maintenance and operational procedures of missiles and aircraft made a distinction by designation necessary. The F-99 became IM-99 for Interceptor Missile, but the sequential number of 99 in the F-for-Fighter (P-for-Pursuit, prior to 1948) series that extended back to the P-1 of 1924 was retained until all US missiles were redesignated in an M-for-Missile series in 1963. The IM-99 then became MIM-10.

Since the Seattle Plant 2 and the Renton factory were both fully devoted to aeroplane production and Plant 1, where the Bomarc prototypes had been built, was not suited to mass production, Boeing acquired new manufacturing facilities by moving into the former automobile assembly plant of the Ford Motor Company situated a mile north of Plant 2. This plant became known as the Missile Production Centre, or MPC.

As Bomarc production phased out, Boeing became the assembly and test contractor for the unique Air Force Minuteman programme. This was a weapon system concept developed by the Ballistic Missile Division of the Air Force and built around a solid-propellant retaliation rocket stored vertically in a bomb-proof underground launching tube, or silo, ready for immediate launch against enemy ground targets up to 5,000 miles distant. Such components as the guidance package, warhead, and the three separate rocket motor stages were made by different manufacturers. Boeing was responsible for bringing all of these together for assembly in a government-owned but Boeing-operated plant at Ogden, Utah, and testing the complete missile (less nuclear warhead) for mechanical, electrical, and electronic readiness prior to delivering it to the Air Force for installation in the silos for periods up to three years. The Minuteman, so named because of its

On January 18, 1957, three B-52Bs completed a nonstop flight around the world. (*Boeing Photo P-17813*)

readiness for launching within a minute of receipt of the launch signal, was originally to have been B-80 in the B-for-Bomber series dating from 1924, but like the F-99 Bomarc it was reclassed as SM-80 to indicate that it was a missile for the attack of surface targets, actually a strategic missile. It became LGM-30 in the general missile reclassification of 1963.

The Minuteman and other emplaced missiles clearly heralded the end of the traditional long-range manned bomber just as the Bomarc and other missiles had taken over the interceptor fighter role. Although the Bomarcs and the Minutemen were given Air Force serial numbers along with conventional aircraft, they are not considered aircraft within the scope of this book and are not illustrated.

MODEL 450 (B-47 series) – Design studies that led to the B-47 began in late 1943, when the Air Force asked the industry to investigate multi-jet aircraft that could be used for the fast photo-reconnaissance or medium bomber missions. As had been done earlier with jet fighters, the first studies merely added jet power plants to traditional straight-wing designs. The initial Boeing study was the Model 424, essentially a scaled-down B-29 with four jet engines paired in two nacelles mounted under the wing. Wind tunnel testing proved the arrangement unsatisfactory, so Boeing sought other locations for the engines in order to increase the efficiency of the wing. The result was Model 432, with all four engines buried in the body. The Air Force awarded a Phase I study contract for this model, designated XB-47, to Boeing at the same time as it awarded jet bomber study contracts to four other manufacturers. Additional Boeing configurations were developed and given wind tunnel tests, but the optimum design that could fully use the capabilities of the jet engines was not attained.

Just after VE-Day, Boeing engineers were allowed to visit Germany and enter the aircraft factories and aeronautical research centres to investigate

The first XB-47 takes off with the aid of its unique built-in JATO system (left) and a B-47E (right) is refuelled by the flying boom system. (*Boeing Photos P-8805 and BW-65779*)

the latest German technology with a view towards adapting significant findings to new American designs for the continuing war against Japan. One of the outstanding items picked up was a study of the effects of wing sweep on the performance of high-speed aircraft that confirmed independent studies conducted by NACA in the United States. Sweep was nothing new; it had been used since before WW-I, mainly to relocate the centre of wing lift relative to the aircraft centre of gravity to permit convenient crew seating or overcome a balance problem. The new technique, involving sweep angles as high as 45 degrees in either a forward or aft direction, allowed a significant speed increase by delaying the formation of shock waves as the wing approached the speed of sound. This appeared to be just what the XB-47 needed, and word was flashed to Seattle to stop work on the straight-wing studies. Prompt wind tunnel tests confirmed the German findings and work went ahead on a new design, Model 448, still with buried engines but with a thin wing swept back at an angle of 35 degrees at the quarter-chord point. The Air Force objected to the vulnerability and safety problems inherent in the buried engine, so further studies resulted in the Model 450 with six external engines. The Air Force approved this design in October 1945 and ordered two prototypes in April 1946.

The B-47 was designed to carry thermo-nuclear weapons of the early postwar type, which were large, heavy, and intended to be dropped from high altitudes over large-area targets deep in enemy territory. Consequently, the bomb bay was large, and could be modified to accommodate a single 22,000 lb conventional explosive bomb. Later, as smaller nuclear weapons were developed for low-level use against pinpoint targets in forward areas, the 'Lob-Bombing' technique originally developed for the smaller fighters was adapted to the B-47s. The aircraft were sent back to the factory for wing reinforcement that would enable them to streak towards the target at high speed just above the ground, pull up in a half-loop, release the bomb when vertical at the quarter-loop point, and then roll out at the top of the loop in a classic Immelmann manoeuvre and be well on the way to safety by the time the bomb came down. This technique with B-47s was first demonstrated to the public in May 1957, nearly a year after completion of B-47 production. Altogether, 2,032 B-47s were built; 1,373 by Boeing, 274 by Douglas, and 385 by Lockheed.

MODEL 450-3-3 (XB-47) – When the first XB-47 rolled out of the Seattle factory on September 12, 1947, it was even more sensational than the original Model 299 Flying Fortress had been. While none of its innovations were actually radical, and some had already been seen on contemporary experimental designs, the combination made the new bomber the most extreme departure from traditional design that the industry had ever seen in what was intended to be a production aeroplane. The swept wing had already been used on the purely experimental Bell L-63, a modified piston-engine fighter, and on the North American XP-86 which flew only two months before the XB-47, but the XB-47 marked its first appearance on a

large American jet. The tandem undercarriage, which had been tested in 1945 on the modified Martin XB-26H, was a necessity on the XB-47 because there was no room in wings, nacelles, or fuselage for the conventional type. With both main two-wheel trucks on the centreline of the fuselage, ground stability was achieved by the use of outrigger wheels that retracted into the inboard nacelles. Since neither main gear was close enough to the aircraft's centre of gravity to permit the traditional rotation method of take-off from a level attitude, the aircraft was built so that it rested on the ground at the proper take-off and landing angle. In flight, the landing gear was used as an air brake, its drag when extended being double the drag of the entire clean aeroplane.

Instead of being in the traditional leading edge nacelles, the six 3,750 lb thrust General Electric J-35 engines were hung under the wings in pods, two pairs in strut-mounted inboard nacelles and single units attached directly under the wing a short distance inboard from the tip. This full-span distribution of the engine weights was structurally efficient and a greatly improved flight control system with artificial feel overcame the traditional yaw problems resulting from loss of power on an outboard engine. Since the acceleration characteristics of the early jet engine were poor compared to piston types, additional thrust for take-off was obtained by building provisions for 18 solid propellant JATO (jet-assisted take-off) rockets inside the fuselage aft of the wing. These units, each with a thrust of 1,000 lb, had been developed during the war to be attached to the outside of heavily loaded bombers and flying-boats to boost take-off power and were dropped after burnout. The empties were carried along on early B-47s. The second XB-47 was fitted with larger 5,200 lb thrust J47-GE-3 engines prior to its first flight and the first was later modified to use the same engines.

The extremely high wing loading of the XB-47, approximately 105 lb/sq ft, coupled with its size and extremely clean design, resulted in a critical braking problem. The JATO system enabled it to take off loaded from most standard military airfields of the time, but the roll-out following a refused take-off or a high gross weight landing on a wet runway was unacceptably long, actually twice that of a B-29. Since the jet engines could not produce reverse thrust and actually produced forward thrust at idle speed, additional braking capability was provided by the use of a 32 ft diameter deceleration parachute that was stowed under the tail. Conventional solid parachutes could not stand the load, so a ribbon type originated in Germany during the war was used with great success. Since the poor acceleration characteristics of the jet engine also made go-arounds after refused landings hazardous, a second and smaller drogue parachute was developed for production B-47s that acted as an in-flight air brake to allow landing approaches to be made at relatively high engine power. If a go-around became necessary, the drogue chute was jettisoned and the aeroplane accelerated quickly because the engines were already producing sufficient thrust. If the landing was normal, the drogue chute was left deployed. It was soon standard practice to deploy the main chute while still a few feet off the ground.

Unique tandem landing gear of XB-47 required auxiliary wheels under inboard nacelles to maintain stability on the ground. (*Photo by Gordon S Williams*)

The extreme flexibility of the thin swept wing introduced controllability problems. The reaction to the deflection of conventional ailerons at the wing tips was to twist the wing in the opposite direction, nullifying or even reversing the aileron action, so spoilers were used on the upper surface to assist turn entry on the test models. This system had been used on the wartime Northrop P-61, and was supplemented, as on the XB-47, by small ailerons. Because of its flexibility, the wing of the B-47 actually drooped when the machine was on the ground, providing another marked contrast to traditional types, practically all of which had noticeable dihedral to their comparatively rigid wings. The B-47 wing tips flexed 5 ft either side of the normal position. Even in flight, the XB-47 appeared to have negative dihedral. While it actually had none, either positive or negative, the swept wing created the impression of droop because the tips of the wing, which was mounted as a positive angle to the centreline of the fuselage, were physically lower than the centre section.

The thin wing had no room for fuel tanks, so all fuel was carried in the fuselage. This brought about a serious problem in fuel consumption management, since the mass of fuel was distributed along a considerable length of the aeroplane and the relative quantities in various tanks would have a serious effect on the balance of the aeroplane. This was not a problem in B-17s and B-29s, where most of the fuel was carried in the wings between the spars and all fuel weight was close to the aeroplane's centre of gravity. Where the B-29 had carried 5,500 gal, the B-47, with its higher fuel consumption, carried 17,000 gal in production models. Fuselage fuel capacity was supplemented by under-wing drop tanks.

Maximum aerodynamic efficency for the wing area used was obtained by the pod mounting of the engines and the high aspect ratio used in combination with the laminar Boeing 145 aerofoil. Rotor drag of an inoperative engine was reduced by closing conical shutters over the inlet. Such attention to detail resulted in an extremely clean overall design that had a power-off glide ratio of 17 to 1.

Not even the armament of the B-47 was conventional. Wartime experience with the stripped high-speed B-29Bs indicated that really fast bombers could be successfully attacked by fighters only from the rear, so only tail armament of two ·50 calibre machine guns was carried in an unmanned tail turret that could be operated manually from the cockpit or be aimed and fired automatically by radar that locked-on to an aircraft

attacking from within the cone of fire provided by the turret. The crew was unusually small for an aircraft of such size and weight, three men performing the functions of pilot, co-pilot, gunner, and bombardier/navigator. First flight of the XB-47 was on December 17, 1947, and the second flew on July 21, 1948.

TECHNICAL DATA - XB-47

Type:	Medium bomber
Accommodation:	3 crew in tandem
Power plant:	General Electric J35, 3,750 lb thrust
Span:	116 ft
Length:	108 ft
Height:	28 ft
Wing area:	1,428 sq ft
Empty weight:	76,000 lb
Gross weight:	125,000 lb (normal), 162,500 lb (overload)
Max speed:	578 mph
Cruising speed:	Not available
Service ceiling:	38,000 ft
Climb:	3,100 ft/min
Range:	4,000 miles (ferry)
Armament:	Two ·50 cal MG, 10,000 lb bombs (normal), 22,000 lb bombs (maximum)

C/ns: 15972, 15973 *USAF serial numbers:* 46-65, 66

MODEL 450-10-9 (B-47A) - A pilot order for ten B-47As, essentially service test versions of the XB-47 to be used for the training of factory and Air Force personnel alike, was placed with the Wichita plant. Powered with 5,200 lb thrust J-47-GE-11 engines and retaining the built-in JATO feature of the prototypes, the first B-47A flew on June 25, 1950. Empty weight was 73,240 lb and maximum take-off weight was 151,324 lb. The tail armament of two ·50 calibre machine-guns was tested with an A-2 fire control system on one machine (49-1906) and an A-5 on another (49-1908). Speed was 521 knots at 8,800 feet. Since the production B-47s were built at Wichita, they used the Stearman system of factory serial numbers keyed to the aircraft model number that had been continued on the Model 75s after Stearman became a Boeing division.

C/ns: 450001/450010 *USAF serial numbers:* 49-1900/1909

A B-47A deploys its braking parachute while still airborne. (*Boeing Photo P-11245*)

Flight view of the B-47B emphasises the high-aspect-ratio 35-degree sweptback wing and the clean installations of the podded engines. (*Boeing Photo BW-60964*)

Although covered by a single bubble canopy, the pilots of this B-47B occupy separate cockpits. (*Boeing Photo BW-93258*)

Unarmed B-47B with ports for internal JATO units visible ahead of insignia. Arrangement of ports varied on different aeroplanes. (*A U Schmidt Collection*)

MODEL 450-11-10 (B-47B) – The B-47B was the first true production B-47, and enough improvements were made during the production of 399 examples to justify the use of additional model numbers, 450-67-27 for the 88th to 289th with J-47-GE-23 engines (5,800 lb thrust) and 450-157-27 for the 290th and on. Empty weight was 76,130 lb and gross weight was 180,000 lb. Top speed was 536 knots at 10,600 ft. In addition to the two ·50 calibre tail guns, which could be fired by the co-pilot (who was also called the weaponeer) or by the radar system, the B-47B carried two K-38 cameras, one K-17, and one K-72.

When the Boeing-Lockheed-Douglas pool was re-established for B-47 manufacture, Boeing supplied aircraft parts and technicians to help the other two firms get started. Lockheed turned out eight B-47Bs with USAF serial numbers assigned to Boeing (51-2097, 2204, 2210, 2217, 2224, 2231, 2237, and 2243) while Douglas produced ten under the same circumstances (51-2141, 2150, 2155, 2160, 2165, 2170, 2175, 2180, 2185, 2186, and 2190). Subsequent Douglas and Lockheed production was on B-47Es under contracts given directly to the two companies. Average B-47B cost with GFE was $2,500,000.

C/ns	*USAF serial numbers*
450011/450015	49-2642/2646
450016/450097	50-1/82
450098/450409	51-2045/2356

B-47Bs underwent considerable modification and redesignation. The 88th B (50-82) was set aside for conversion to XB, later YB-56 with four

Experimental B-47B with larger J57 engine in outboard pod. (*Boeing Photo BW-91701*)

Allison J-71 engines and reconnaissance equipment in place of bombs. This was redesignated YB-47C, but was cancelled along with projected RB-56A versions. Two were fitted with propellers as XB-47D and are described under Model 450-162-48. B-47B variants are listed below:

• YDB-47B – B-47B 51-2186 modified in 1953 to carry a Bell GAM-63 Rascal missile, which was guided to the target by a controller in the same B-47 after the missile was released.

• DB-47B – Armament deleted from 74 B-47Bs fitted with radio for controlling QB-47s and other remotely-controlled craft.

USAF serial numbers: 51-2160, 2162/2234

• RB-47B – Twenty-four B-47B photo-reconnaissance conversions with eight cameras in a heated capsule in the bomb bay.

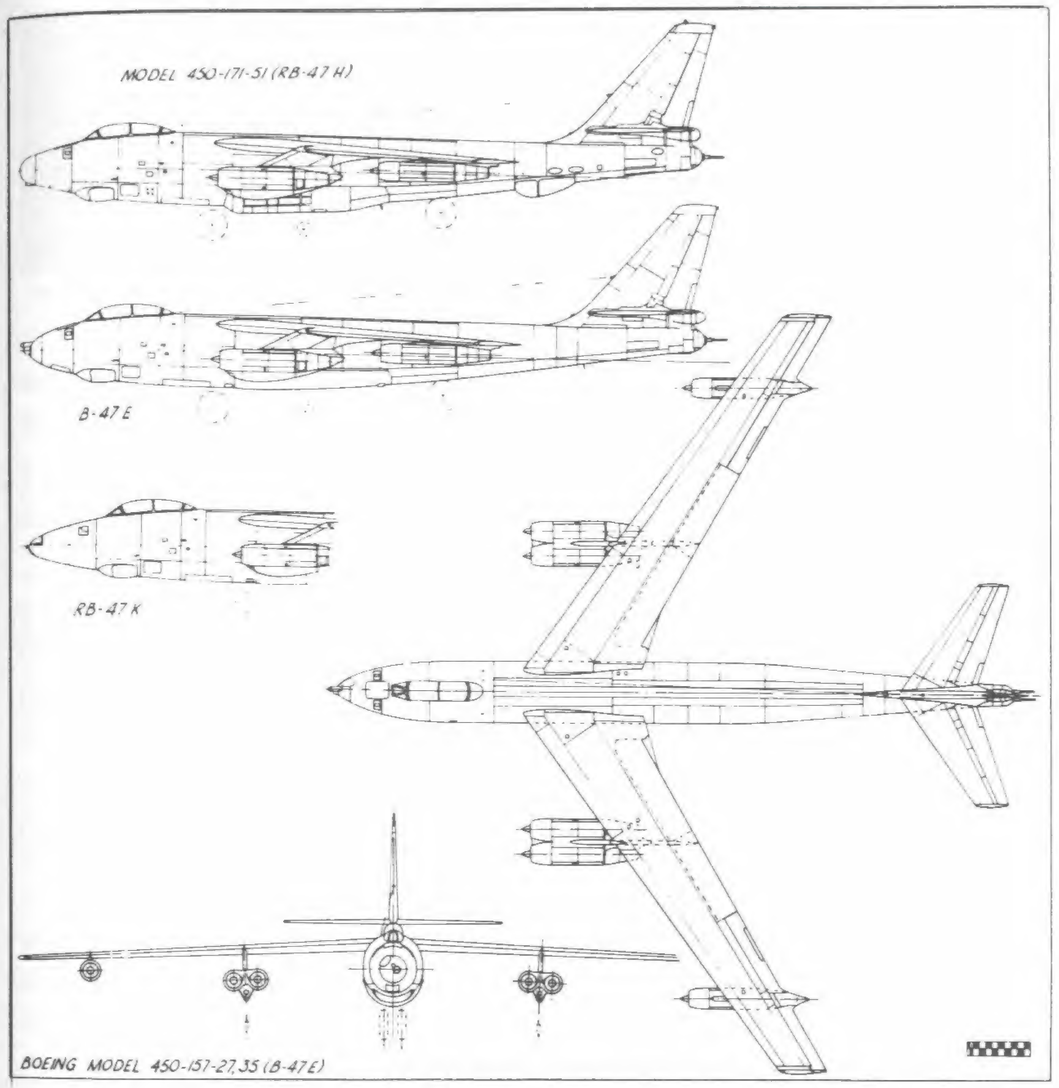
• TB-47B – Transition trainers for pilots and navigators were developed from standard B-47Bs by adding a fourth crew position for an instructor. Forty-eight were modified by Douglas at Tulsa and 18 were modified by the Air Force at Oklahoma City.

• WB-47B – One B-47B-BW (51-2115) modified for weather reconnaissance.

• B-47B-II – B-47Bs modified and brought up to B-47E standard.

MODEL 450-157-35 (B-47E) – This was a major milestone in the B-47 programme and involved many changes. J-47-GE-25 engines were fitted, with thrust increased to 7,200 lb by water injection. The 18-unit internal JATO system was retained on early models but was soon replaced by a jettisonable rack that contained thirty-three 1,000 lb thrust units which could be dropped in open country or over water after take-off. Armament was changed to two 20 mm cannons and fuel capacity was reduced to 14,610 gal including two 1,700 gal wing tanks. The undercarriage and other structure were reinforced for the greater weight. The entire nose section was revised to incorporate an in-flight refuelling receptacle on the starboard side of the nose and three ejection seats, two firing upward for the pilot and co-pilot and one downward for the bombardier/navigator. The under-surfaces and lower portion of the fuselage of most B-47Es were painted a glossy white to reflect heat and radiation from nuclear blasts. No national

Boeing-built B-47E with 1,500 gal auxiliary fuel tanks under the wings. Blue band with white stars around nose is Strategic Air Command insignia. (*Photo by Peter M Bowers*)



markings or other large paint areas were applied over this reflective paint, which was also applied retroactively to some B-47Bs.

Boeing built a total of 931 B-47Es. One was redesignated YB-47J to test a new MA-2 radar bomb sight and an additional 15 were completed as RB-47K. Douglas built 274 B-47E-DT and Lockheed built 385 B-47E-LM at an average cost of $1,870,000. B-47E variants are described after the technical data and the RB-47E is described under a later Boeing model number, 450-158-36.

B-47E takes off with the aid of thirty-three external solid-fuel JATO units. (*Boeing Photo P-17548*)

TECHNICAL DATA - B-47E-II

Dimensions:	As earlier models
Accommodation:	As earlier models
Power plant:	J-47-GE-25, 7,200 lb thrust with water injection
Empty weight:	80,756 lb
Gross weight:	206,700 lb (198,180 lb take-off limit with JATO and water/alcohol)
Max speed:	606 mph at 16,300 ft
Cruising speed:	557 mph at 38,500 ft
Climb:	2,430 ft/min with normal power, 4,660 ft/min water injection
Service ceiling:	40,500 ft
Ferry range:	4,035 nautical miles at 433 knots
Armament:	10,000 lb bombs, two 20 mm cannon with 70 rounds

Aircraft	*C/ns*	*USAF serial numbers*
B-47E-BW	450410/450498	51-2357/2445
B-47E-BW	450499/450542	51-5214/5257
B-47E-BW	450562/450626	51-7019/7083
B-47E-BW	450627/450659	51-15821/15853
B-47E-BW	450679/450905	52-394/620
B-47E-BW	4501074/4501230	53-2261/2417
B-47E-BW	4501231/4501268	53-4207/4244
B-47E-BW	4501334/4501387, 4501390	53-6193/6246, 6249
B-47E-LM	Unknown	51-15804/15812
B-47E-LM	Unknown	52-202/393
B-47E-LM	Unknown	53-3343/3373
B-47E-LM	Unknown	53-1819/1972
B-47E-DT	43634/43669 } 43751/43816 }	52-19/120
B-47E-DT	44000/44055	52-146/201
B-47E-DT	44090/44101	52-1406/1417
B-47E-DT	44149/44161	53-2028/2040
B-47E-DT	44436/44516	53-2090/2170

• YDB-47E - Two B-47Es (51-5219, 5220) were completed at Wichita in January 1954, as YDB-47E for service tests with the Bell GAM-63 Rascal missile, which was suspended from the starboard side of the fuselage behind the wing. After the missile was released, it was guided to the target by radio control from the YDB-47E. Unrefuelled combat radius was 1,230 miles

The YDB-47E carrying the Bell GAM-63 Rascal guided missile. (*Boeing Photo P-14224*)

RB-47E was photo-reconnaissance version of the standard bomber and could be distinguished by elongated nose. The last fifteen were completed as RB-47K. (*E M Sommerich Collection*)

with 18,000 lb payload at 426 knots. These modifications resulted in model number change to 450-167-50.

• DB-47E - Two additional B-47E conversions (53-2345, 2346) essentially similar to YDB-47E except given Boeing designation 450-172-52.

• EB-47E - Two modified B-47Es redesignated EB-47E were loaned to the US Navy and remained operational after the last USAF B-47s were retired. One of these, EB-47E-45-DT, made the last flight of a B-47 when it was ferried with civil registration N1045Y from Davis-Monthan AFB in Arizona to an aviation museum in Colorado.

• QB-47E - Two B-47Es were converted to prototype radio-controlled drones for use as targets and other tasks hazardous to human occupants. Twelve additional 'production' versions were delivered by June 1960. In spite of being unmanned, the Q-planes were still extremely costly items and were not considered expendable targets. The guided missiles used against them were programmed to make near misses, but even so, one QB-47 was inadvertently destroyed by a direct hit from a Bomarc missile.

MODEL 450-158-36 (RB-47E) - Two hundred and forty Wichita-built B-47Es were completed as RB-47E for strategic photo-reconnaissance missions. The first 52 were completed under the Boeing designation of 450-126-29. Major outward change from the standard E was a slight

The two US Navy EB-47Es. (*US Navy Photo*)

lengthening of the nose and a return to the built-in JATO units. The bombing equipment was deleted and the bombardier became the photographer/navigator, but the 20 mm tail armament and A-5 fire control system were retained. Eleven cameras were carried along with 10 photo flash bombs and supplementary photo flash cartridges for night photography. First RB-47E flight was in August 1953. Maximum speed was 497 knots (572 mph) at 20,000 ft. Take-off gross weight was 100,000 lb, which could be increased to 202,000 lb by in-flight refuelling after take-off. Maximum fuel capacity was 18,405 gal.

C/ns	*USAF serial numbers*
450543/450561	51-5258/5276
450627/450659	51-15821/15853
450906/4501046	52-685/825
4501047/4501073	52-3374/3400
4501269/4501288	53-4245/4264

MODEL 450-162-48 (XB-47D) - Two B-47Bs (51-2046 and 2103) were converted to XB-47D to serve as test beds for the Wright YT-49-W-1 turboprop engines. One of these was installed in place of the paired J-47s in each inboard nacelle. The outboard J-47-GE-23 jets were retained. To

Two XB-47Ds were converted from B-47B to serve as test beds for T49 turboprop engines. (*Boeing Photo P-15582*)

absorb the 9,710 equivalent shaft horsepower of the T-49, four extremely wide blades were used on the 15 ft diameter propellers. No armament was fitted. Empty weight was 79,800 lb, and take-off gross weight was 184,428 lb. Maximum speed was 519 knots (597 mph) at 13,500 ft, the fastest achieved in level flight by a propeller-driven aircraft, and service ceiling was 33,750 ft. Rate of climb at normal power was 2,910 ft/min. The first XB-47D to fly was 51-2013, in July 1955. The second, with minor revisions, was designated Model 450-162-49.

MODEL 450-171-51 (RB-47H) - Thirty-two Wichita-built B-47s were

completed as RB-47H for special reconnaissance missions, intended to detect and locate surface radar stations. Normal crew was pilot, co-pilot, and observer, but an additional three could be carried in the bomb bay with the special equipment. First flight in June 1955. Empty weight was 83,462 lb, with allowable take-off weight of 220,000 lb and an allowable flight gross of 221,000 lb. Take-off was assisted by 33 external JATO units. Maximum speed was 523 knots (602 mph) at 15,000 ft.

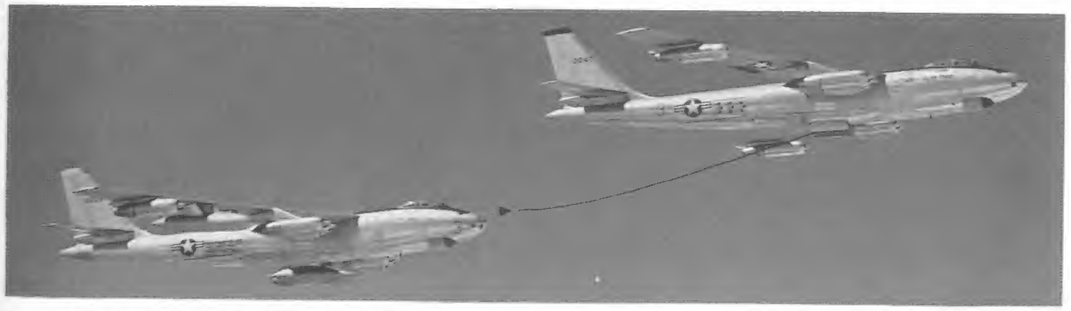
C/ns	*USAF serial numbers*
4501304/4501333	53-4280/4309
4501388, 4501389	53-6247,6248

• ERB-47H - Three B-47Es (53-6245, 6246, 6249) were converted to ERB-47H configuration similar to that of the RB-47H.

CONVERTED B-47s

Because of extensive changes, some converted B-47s were given separate series designations without new Boeing model numbers instead of merely receiving sub-designations within the original series as was done with DB-47B, B-57B-II, etc.

• YB-47F - Standard B-47B 50-69 equipped with a probe for in-flight refuelling by the probe-and-drogue system from the single KB-47G hose tanker. The method did not prove practical for the B-47 and in-flight refuelling of subsequent models was by the established flying boom system.



The KB-47G refuels the YB-47F by the experimental hose-and-drogue system. (*Boeing Photo P-13353*)

• KB-47G - Standard B-47B 50-40 modified to serve as an experimental hose tanker for the YB-47F. Testing was also conducted with Republic F-84G before the experiment was abandoned.

• YB-47J - The single YB-47J was a standard bomber modified to carry and evaluate the new MA-2 radar bombing-navigation system.

• RB-47K - An additional fifteen RB-47E aircraft on order were completed as RB-47K and differed from the E in being equipped for both weather and photo reconnaissance at all altitudes.

• EB-47L - Thirty-five obsolescent B-47Es modified in 1963 as EB-47L electronic communications aircraft to serve as relay stations between other aircraft or ground stations.

B-47 used by the RCAF as a flying test bed for the Canadian-built Orenda Iroquois turbojet engine. (*Boeing Photo BW-115220*)

• B-47B/CL-52 – In 1956, one B-47B, 51-2059, was transferred to the RCAF which gave it the special serial number of X-059 and turned it over to Canadair, Ltd for use as a test bed for the 20,000 lb thrust Orenda Iroquois turbojet engine. The modified B-47 was designated CL-52 by Canadair when fitted with a separate pod for the test engine on the starboard side of the fuselage under the horizontal tail.

MODEL 464 (B-52 series) – While the configuration of the B-52 as it was finally built gave the impression of being merely an enlarged B-47, the two designs were initially developed along entirely separate lines. Boeing was awarded a study contract for a long-range heavy bomber designated XB-52 in June 1946. Although jet propulsion had been adopted for smaller bombers then under development, the high fuel consumption ruled against its use in long-range aircraft. The Boeing Model 462 was offered to the Air Force as a straight-wing bomber powered by six 5,500 hp Wright T-35 turboprop engines. It fell short on range, and a revised design using only four improved T-35s of 8,900 hp was proposed. This was accepted, but while the details were being worked out, Boeing went ahead with company-financed studies of a pure-jet bomber for the same mission that could use a new jet engine then under development by Pratt & Whitney.

In October 1948, a team of Boeing's top designers went to Wright Field to discuss final details of the turboprop model with the Air Force. They

The XB-52 under security wraps before being rolled from the final assembly building at Plant 2 to the Flight Test Centre, November 29, 1951. (*Boeing Photo P-12377*)

were told that Air Force studies had indicated that the existing design was incapable of doing its assigned job. The turboprop project would be cancelled, but the Air Force was interested in a comparable model using the new Pratt & Whitney J57 jet engine and asked what Boeing could do in that direction. The events of the next few days read almost like fiction. The Boeing team took the new Air Force requirements back to their Dayton hotel and studied them. The next morning, a Friday, they telephoned the project officer at Wright Field to tell him that a new Boeing proposal would be submitted on Monday. Working feverishly over the weekend and using memory of recent research supplemented by some information on the private jet bomber studies that had been brought to Dayton in their briefcases, six engineers worked out the basic design of a new eight-jet swept swing heavy bomber. Typed by a public stenographer and accompanied by a balsa wood model that one engineer built with materials obtained from a local hobby shop, the proposal was submitted to the Air Force as promised on Monday. Further detailed studies of the new design were authorized, still under the designation of XB-52. The new studies resulted in an order for two prototypes, the first of which rolled out of the factory in November 1951. Meanwhile, the design studies and wind tunnel tests had been so convincing that the Air Force issued Boeing a Letter of Intent for the manufacture of production B-52 tooling in March 1951, more than a year before the first experimental flight test.

Like the B-47, the B-52 saw many changes in the nature of its primary mission affect structural and equipment details during its production life. Originally a high-altitude bomber intended to deliver nuclear warheads over the target, it was adapted both to stand-off missions where it launched aerodynamic or ballistic missiles hundreds of miles from the target and to extreme low level attacks that achieved surprise by staying below the level of enemy detection systems. Extensive structural modification was necessary to qualify the B-52 for low-altitude missions. In all, 744 B-52s were built.

MODEL 464-67 (XB-52, YB-52) – Two prototypes of the Stratofortress, as it was named by Boeing, were built. General layout was similar to the B-47, with swept wing and tail surfaces having higher taper ratios. The basic tandem landing gear feature was retained, along with the braking parachute, which was enlarged to 44 ft. A notable difference was that four separate two-wheel landing gear trucks were used. These were sufficiently far apart across the fuselage centreline to permit the B-52 to stand level on the ground, but wing tip protection gear were still necessary for ground stability during taxiing. When the wing tanks were full the wing drooped and both tip gear came in contact with the ground. Since few military bases with runways long enough for the B-52 had multiple runways for use with different wind directions, the four main landing gear trucks were made movable so that the aircraft could be crabbed into the wind on a cross-wind landing while the wheels were aligned with the runway.

The wing was swept 35 degrees as on the B-47 and used a Boeing 233

First flight of the YB-52, April 15, 1952. (*Boeing Photo P-12139*)

aerofoil at the root and a Boeing 236 at the tip. However, while the planform taper was straight, the thickness taper was not constant. Viewed from the front, the upper and lower wing surfaces appeared to be convex instead of straight lines from root to tip. This feature had been incorporated on the B-47, but was not nearly as noticeable.

Flight controls were hydraulically operated, and originally consisted of combined flaps and ailerons, or flaperons. These were soon abandoned on the prototypes and slotted spoilers on the upper surface of the wing were used for lateral control. Conventional elevators were not used for pitch control. Instead, the whole horizontal tail was made movable in the manner that was becoming standard on jet fighters but had never been used on large aircraft before. Power for operation of the aircraft systems was provided by four unique turbines in the forward wheel wells driven by high-pressure air

Pilot's cockpit (forward) of XB-52. Note eight throttles at lower left and that gyro magnetic compass is missing from instrument panel. (*Boeing Photo FA-10562*)

bled from the second compression stage of the J57-P engines. The turbines drove alternators.

As on the B-47, only rearward-firing tail armament was fitted. This could be controlled manually by a tail gunner or operated automatically by the MD-5 radar fire control system. The original B-52 crew consisted of pilot, co-pilot, bombardier, navigator, and tail gunner. The exterior feature that distinguished the prototypes from their successors was the tandem arrangement of the pilot and co-pilot under a single bubble canopy on the pattern of the B-47.

• XB-52 – The five-seat XB-52 was rolled out of the factory and was transferred to the flight test hangar under concealing tarpaulins on the night of November 29, 1951. After systems and taxi testing, it was returned to the factory for installation of new features and did not fly until October 2, 1952.

• YB-52 – Outwardly identical to the XB-52, the YB-52 left the factory on March 15, 1952, and made its first flight on April 15. Both prototypes were used extensively in test and development work for several years and underwent many changes in equipment and controls, including the short tail for the B-52G and H models. The spoiler lateral control system of the YB-52 used six instead of three panels per wing as used on the XB-52, and supplemented these with flaperons. Small tab-operated ailerons were later added to the XB-52.

The YB-52 was retired in 1958 and replaced on permanent display in the Air Force Museum at Wright-Patterson Air Force Base, Ohio.

TECHNICAL DATA - XB-52, YB-52

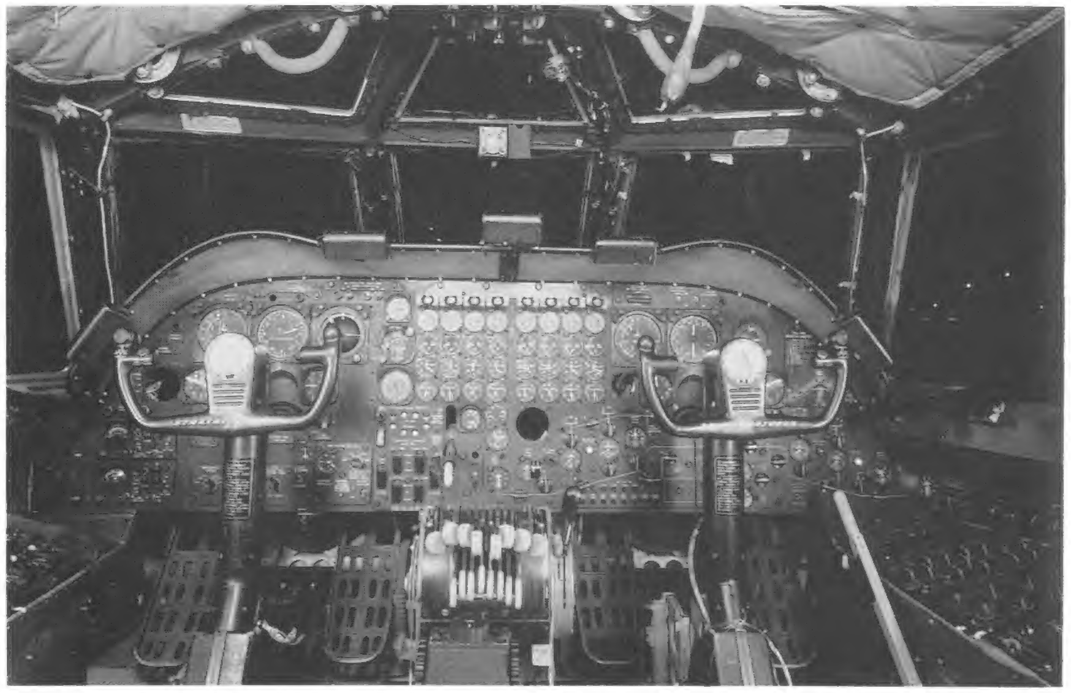
Type:	Long-range bomber
Accommodation:	5 crew
Power plant:	8 axial-flow P & W YJ57-8-3, 8,700 lb thrust
Span:	185 ft
Length:	152·67 ft
Height:	48·25 ft (21·5 ft folded fin)
Wing area:	4,000 sq ft
Empty weight:	160,000 lb
Gross weight:	390,000 lb
Max speed:	483 knots (556 mph) at 40,000 ft
Cruising altitude:	39,000 ft
Range:	5,200 miles
Armament:	Four ·50 cal MG, 10,000 lb bombs

C/ns	*USAF serial numbers*
(XB-52) 16248	49-230
(YB-52) 16249	49-231

MODEL 464-201-0 (B-52A) – Three B-52As were built out of 13 ordered with the first flight on August 5, 1954. The remaining 10 became B-52B. The three As were returned to Boeing by the Air Force immediately after acceptance for use in the test programme. Major outward difference from

Nose of the B-52A and subsequent models was revised for side-by-side seating of pilot and co-pilot. White cross on black square is phototheodolite target. (*Boeing Photo P-15059*)

the prototypes was a modified nose to provide the pilot and co-pilot with side-by-side seating. Normal crew was six, with upward ejection seats for three and downward ejection seats for two in the nose section. The tail gunner, who reached his separate pressurized tail turret under unpressurized flight, could escape by jettisoning the entire tail turret. Power plants were J-57-P-9W fitted with water injection, 360 gal of water being carried in a rear fuselage tank for the purpose. While the B-52A was equipped for in-flight refuelling by the Boeing flying boom, unrefuelled range was increased by the installation of two 1,000 gal auxiliary fuel tanks to supplement the normal fuel load of 35,600 gal. One B-52A,52-3, was



Side-by-side pilots' cockpit of the B-52A. Note eight sets of engine instruments centred between the pilots. (*Boeing Photo 142909*)

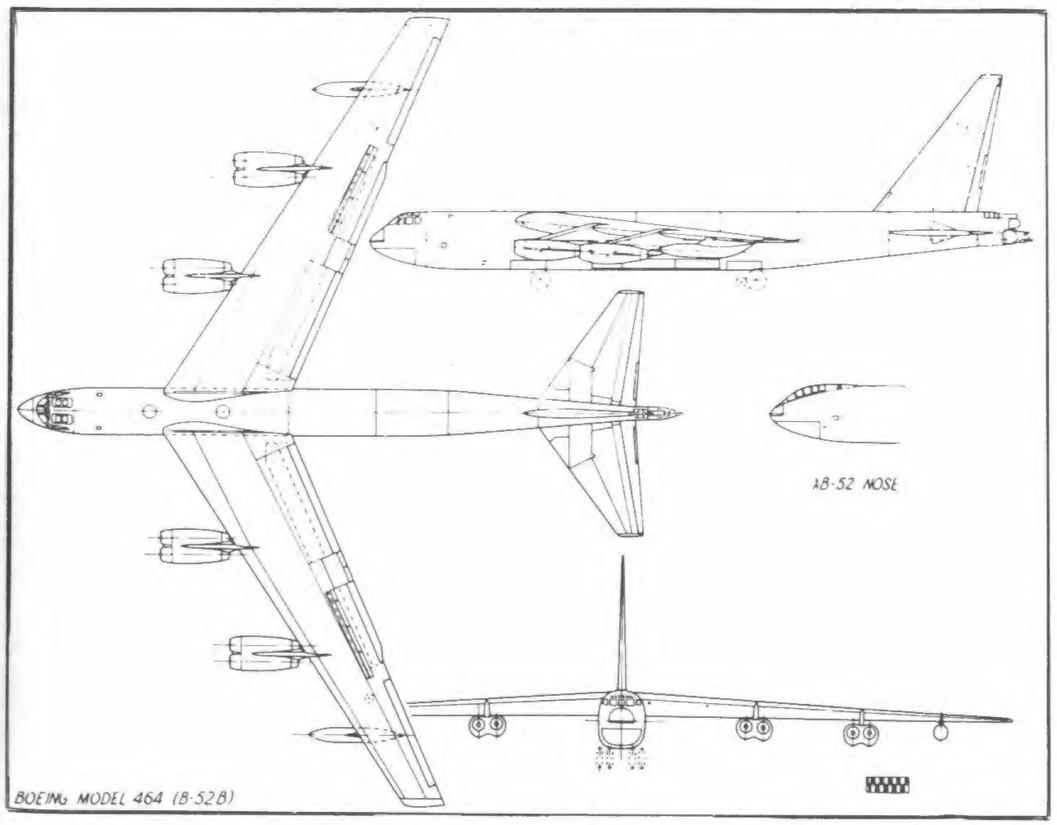
redesignated NB-52A in 1959 and modified to carry the North American X-15 rocket-powered research aeroplane under the right wing between the fuselage and the inboard nacelles. The B-52As were carried on Air Force records at the fantastic price (for the time) of $29,000,000 each, but it must be realized that these were essentially experimental aircraft with much of the initial tooling and development costs charged against them.

C/ns: 16491/16493
USAF serial numbers: 52-1/3

MODEL 464-201-3 (B-52B, RB-52B) – Essentially production versions of the B-52A with increased gross weight and outwardly indistinguishable from it. The original B-52A order was for 13 aeroplanes, but the last 10 incorporated changes of the later B-52B and were redesignated bringing total B production to 50 at a cost of $14,400,000 each.

• B-52B – Principal change was replacement of the J-57-P-9W engine with the improved J-57-P-19W, 29W, and 29WA engines. Only twenty-three B-52Bs were completed in the standard bomber configuration. On January 18, 1957, three B-52Bs completed a nonstop flight around the world in 45 hr 19 min at an average speed of 520 mph for the 24,325 miles.

C/ns 16852/16855 16859/16877 *USAF serial numbers:* 53-373/376 53-380/398



Obsolete B-52B redesignated NB-52B and used as flying launch platform for North American X-15 research aircraft. Note cutout in wing. (*Photo by Peter M Bowers*)

• RB-52B – The remaining B-52Bs were given the R-for-reconnaissance prefix because they could be used for two primary missions. Provision was made for the installation of a removable two-man pressurized capsule in the bomb bay to carry cameras or electronic countermeasures equipment.

C/ns	*USAF serial numbers*
16494/16503	52-4/13
16838/16844	52-8710/8716
16845/16851	53-366/372
16856/16858	53-377/379

MODEL 464-201-6 (B-52C) – Further improvements to the RB-52B with gross weight increased to 450,000 lb and unrefuelled range extended by the use of 3,000 gal auxiliary fuel tanks to bring the total to 41,700 gal (271,000 lb). The water injection system was changed to use two 150 gal tanks in the leading edges of the wing roots. The first of 35 B-52Cs flew on March 9, 1956. This was the first B-52 model to use the white thermal reflecting paint on the under surfaces, although it was applied to B-52Bs already in service. One RB-52B, 52-8, was modified to NB-52B to carry the X-15.

C/ns	*USAF serial numbers*
16878/16887	53-399/408
17159/17183	54-2664/2688

RB-52B with deceleration parachute deployed and wing spoilers extended. Auxiliary fuel tanks under wings hold 700 US gallons each. (*Boeing-Wichita Photo BW-93699*)

B-52D with 3,000 gal auxiliary fuel tanks releases McDonnell ADM-20 (formerly GAM-72) Quail decoy missile from the bomb bay. (*Boeing Photo P-21614*)

MODEL 464-201-7 (B-52D) – The B-52D was essentially the B-52C reconverted to a standard bomber without the alternate reconnaissance capsule feature. It was built both in Seattle and in Wichita, the 101 Seattle-

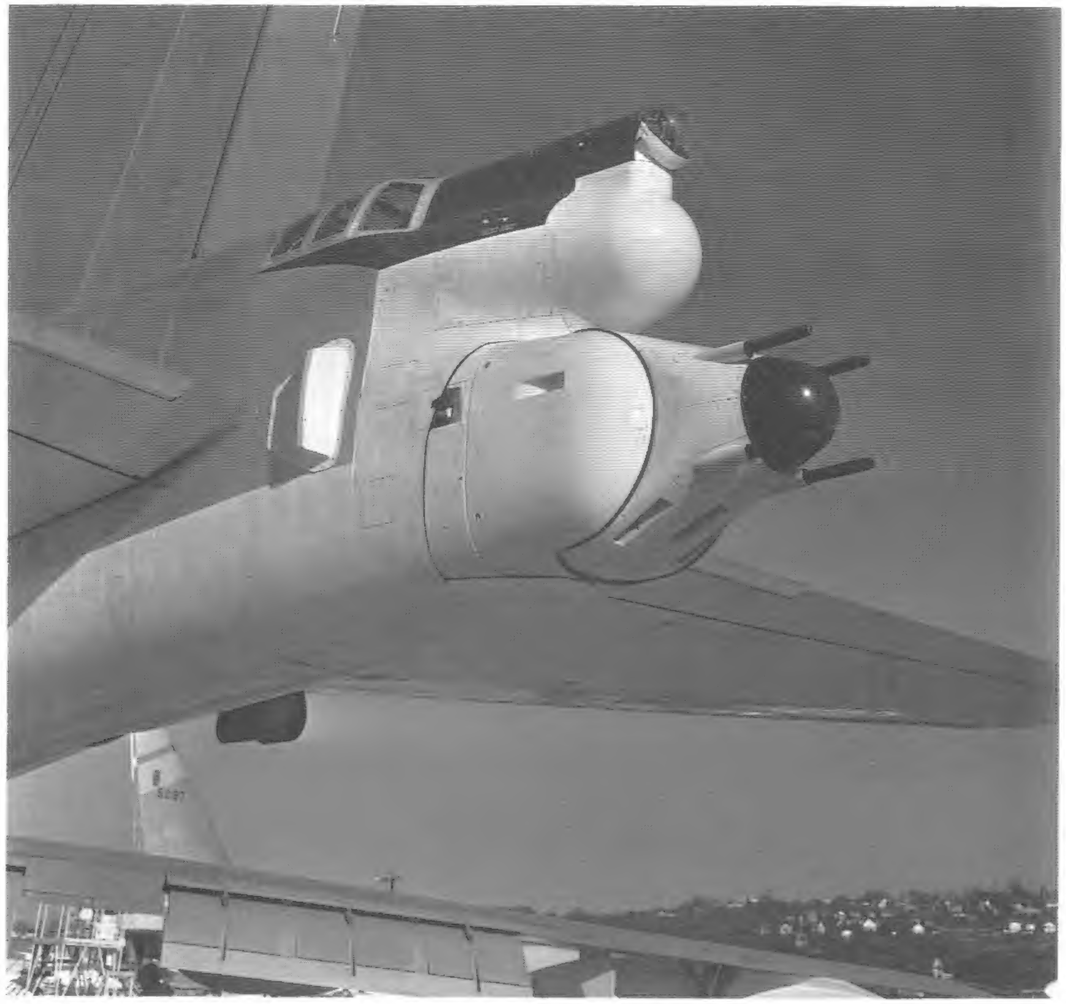
Wichita-built B-52D approaches a KC-97 for refuelling. Note that the undercarriage has been lowered to add drag to match the lower speed of the piston-engine tanker and how the wing curves upward during slow flight at high angles of attack. (*Boeing-Wichita Photo BW-94186*)

built aircraft using the Seattle serial numbers while the 69 Wichita-built models used the old Stearman system.

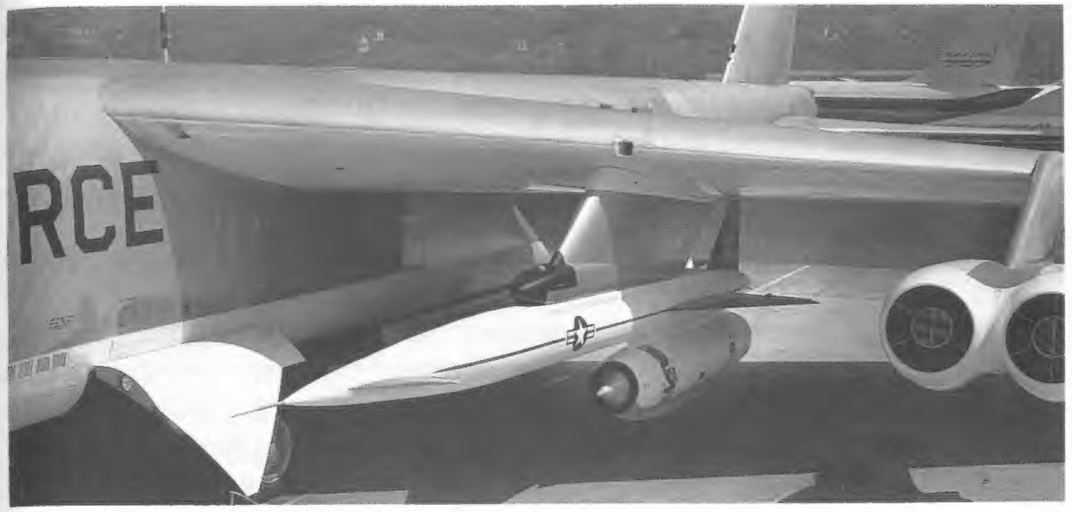
C/ns	*USAF serial numbers*
464001/464019 (W)	55-49/67
17184/17233 (S)	55-68/117
464020/464027 (W)	55-673/680
17263/17313 (S)	56-580/630
464028/464069 (W)	56-657/698

MODEL 464-259 (B-52E) – Essentially B-52Ds with improved bombing, navigation, and electronics systems. Forty-two built in Seattle and 58 at Wichita. First flight was on October 3, 1957, and the cost was the lowest of any B-52 – just over $6,000,000.

C/ns	*USAF serial numbers*
17314/17339 (S)	56-631/656
464070/464083 (W)	56-699/712
17408/17423 (S)	57-14/29
464084/464127 (W)	57-95/138



Tail gun installation of Wichita-built B-52E. (*Boeing Photo P-17804*)



The first B-52E, used as a test mount for the Northrop AGM-28 (formerly GAM-77) Hound Dog supersonic missile carried by later B-52G and H models. (*Boeing Photo P-21529*)

MODEL 464-260 (B-52F) – Production of this model was divided almost evenly between Seattle and Wichita and it was the last of the B-52 series built in Seattle. Following completion of the last B-52F-BO in November 1958, all engineering responsibility for the B-52 was transferred to Wichita. Outwardly, the F was identical to the E. The most significant change was deletion of the air-driven turbines and alternators in the fuselage. These were replaced by four 40 KVA alternators, one attached to the left-hand unit of each pair of 13,750 lb thrust J-57-P-43W engines. Water injection capacity was increased by installation of two additional wing tanks.

C/ns	*USAF serial numbers*
17424/17467 (S)	57-30/73
464128/464172 (W)	57-139/183

MODEL 464-253 (B-52G) – This was the major production model of the B-52 series, which first flew on October 26, 1958, and 193 were built. Many major changes were made, the most noticeable being a reduction in the size of the vertical fin, replacement of the 3,000 gal auxiliary tanks with the 700 gal size of the B-52B, deletion of the ailerons, and modification of the tail cone. Internal fuel capacity was increased to 46,000 gal (312,000 lb) by additional tanks and replacement of the rubber tank structure with integral

Distinguishing feature of B-52G was shortened height of vertical tail. (*Photo by Peter M Bowers*)

tanks. The water injection system was revised and duration increased by installation of a single 12,000 gal tank in the forward fuselage. The tail gunner was moved forward into the nose section to operate his four-gun tail turret by remote control or through the automatic fire control system. This resulted in the revised tail cone shape and relocation of the deceleration parachute compartment.

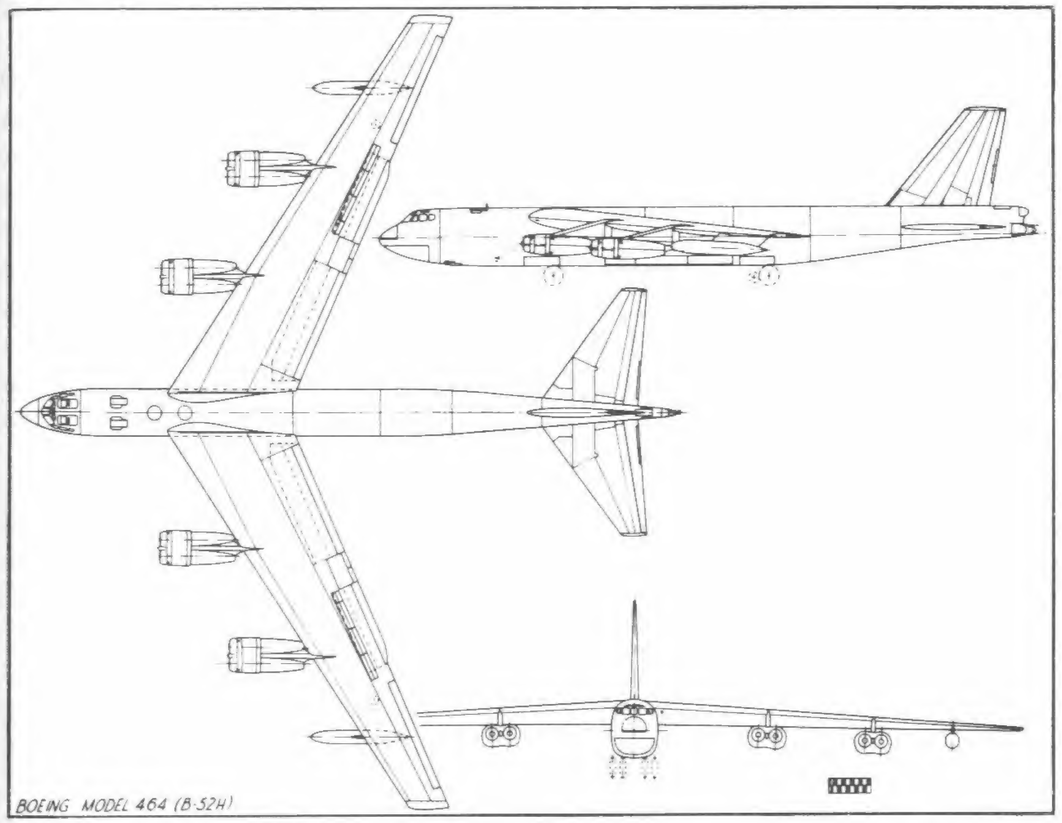
While the B-52G is equipped as a standard bomber, it can also carry two North American AGM-28 (formerly GAM-77) Hound Dog missiles, one on a pylon under each wing between the inboard nacelles and the fuselage. The AGM-28 is actually a small supersonic jet bomber, powered with a 7,500 lb thrust J-52 engine and equipped with its own inertial guidance system and a four-megaton nuclear warhead. It can be launched several hundred miles from the target and reach it without guidance from the crew of the B-52G. These missiles actually make the B-52G a ten-engine bomber when their engines are used to assist take-off. Fuel used during this operation is replaced in flight from the B-52 fuel system. The B-52G can also carry a pair of McDonnell ADM-20 (formerly GAM-72) Quail decoy missiles in the bomb bay. The ADM-20 is a small delta-wing drone powered with a 2,450 lb J-85-GE-7 engine that flies at the same speed and altitude of the B-52 after launch and contains electronic devices that make it look like a B-52 on enemy radar scopes.

C/ns	*USAF serial numbers*
464173/464225	57-6468/6520
464226/464326	58-158/258
464327/464365	59-2564/2602

MODEL 464-261 (B-52H) - The last of the big production bombers, developed specifically as a carrier for four Douglas GAM-87A Skybolt two-stage solid propellant ballistic missiles which had a range of 1,150 miles and could be fitted with nuclear warheads. Cancellation of the Skybolt

B-52H has short tail and Hound Dog armament of the B-52G but is distinguished by the larger inlets of TF33 turbofan engines. (*Boeing Photo P-32058*)

programme resulted in diversion of the B-52H, which made its first flight on March 6, 1961, to other missions, including carriage of the AGM-28 Hound Dog. Principal changes from the B-52G are use of a six-barrel Gatling Gun automatic cannon in the tail turret and new 17,000 lb thrust TF-33-P-3 turbofan engines. The mechanics of this new type of jet engine, actually a modified J57 and called either a bypass or fan engine, alters the appearance of the nacelle. The first three compression stages of the standard



J57 have been replaced by two larger diameter fan stages to take in two and one-half times the weight of air used by the J57. This larger size and the requirement to exhaust bypass air around the whole diameter of the engine results in the distinctive shroud or sleeve on the forward portion of the nacelle. This use of fan engines on the B-52 followed their adoption on the commercial jet transports.

On January 11, 1962, a B-52H flew nonstop from Okinawa to Spain to set a new non-fuelled distance record of 12,519 miles. This record stood until December 1986. The last B-52H rolled out of the factory on June 22, 1962, and was delivered to SAC on October 26.

C/ns	*USAF serial numbers*
464366/464427	60-1/62
464428/464467	61-1/40

B-52 POST-PRODUCTION MODIFICATIONS

Because of high-level politics and the technical shortcomings of other

designs, the B-52 found itself in the unique position of outliving two much more modern designs that were expected to replace it. A continuing series of structural and electronic improvements have kept the now venerable B-52 abreast of changing tactical and strategic conditions and more than quadrupled the expected service life from less than 5,000 flying hours to over 21,000 hours. Because of this extended life and the absence of a suitable replacement in production at the time of writing (1988), the 265 B-52G and H models now in service are expected to remain active until at least the year 2000, 38 years after the last B-52H was built.

The first intended B-52 replacement was the North American XB-70 Valkyrie, a supersonic delta-wing design. Boeing was to have built the wings of the production models in Seattle, but the programme was cancelled after only two prototypes were built. The second intended replacement was the Rockwell (formerly North American) B-1, a more conventional supersonic bomber with variable-sweep wings. Again, Boeing was involved, this time with responsibility for the military electronics. In an economy move, the Carter Administration cancelled the B-1 programme in 1977. It was re-established by the Reagan Administration in 1981 with an order for one hundred B-1Bs. However, these will merely supplement, not replace, the B-52 for the remainder of the century.

STRUCTURAL MODIFICATIONS – Subsequent to the structural changes incorporated during production to suit the B-52 to low-level penetration missions, post-production changes were made to extend airframe life. Mainly, this consisted of extensive rebuilding of the wing, including replacement of the leading and trailing edges, much upper and lower skin with 2,024 aluminium fasteners, and replacement of all wing wiring. The upper portion of the central fuselage was re-skinned and the engine pylons were modified. Eight B-52Ds were so modified at a cost of approximately $2 million per aeroplane, the last returning to service in February 1977.

MILITARY SYSTEMS UPDATES – In its post-production years the B-52 acquired many new military electronics systems that did not exist when the aeroplane was built. These added a profusion of radomes and antennae to the heretofore smooth exterior. Although the additional systems took up internal space, extensive state-of-the-art miniaturization of the components minimized the space problem. Starting in 1964, after the end of B-52 operations over Vietnam, the major electronic additions to the B-52 have been the Phase VI countermeasure system, the AN/ASQ-151 Electro-Optical Viewing System (EVS) for low-altitude penetration missions. The system uses two nose turrets, one on the right containing a forward-looking infra-red scanner and the one on the left containing an AVQ-22 low-light-level TV camera for the pilot's use. Next came further countermeasures equipment, designated SNOE for Smart Noise Operation Equipment, and improved communications equipment that permits world-wide communication via satellite. The final upgrade, applied in the early 1980s to B-52G and H models, is an Offensive Avionics System (OAS) to upgrade navigation and weapons delivery capability.

ORDNANCE UPDATES – In December 1965, six months after the start of B-52 operations over Vietnam, the entire B-52D fleet was modified to accommodate a greater load of conventional, or so-called 'Iron', bombs. Up to eighty-four 500 lb bombs or forty-two 750 lb bombs can be carried internally, plus an additional twenty-four 750 lb bombs under the wings, twelve at each of the pylon positions previously used for Hound Dog missiles. A mix of eighty-four 500 lb and twenty-four 750 lb bombs results in a bomb load of 60,000 lb, equivalent to the combined loads of eight Second World War B-17Gs. Normal Iron bomb load for other B-52 models was 20,000 lb.

The original AGM-28 Hound Dog missiles were phased out in the 1970s and replaced by smaller subsonic Boeing AGM-69 Short Range Attack Missiles (SRAM). The B-52 can carry 20, eight on a rotary launcher in the bomb bay and six on a pylon under each wing.

In 1982–83 the SRAMs were supplemented by a new subsonic Air Launched Cruise Missile (ALCM) on the B-52Gs and B-52Hs. Twelve of these can be carried on the two external pylons in addition to the mix of SRAMs and other weapons in the bomb bay.

The carriage of ALCMs in those B-52Gs equipped to launch them resulted in a unique modification. Under the provisions of the Strategic Arms Limitations Treaty (SALT) between the United States and Soviet Union, ALCM-carriers had to be distinguishable from similar aeroplanes that did not carry them. Since not all of the B-52Gs were ALCM carriers, only those so modified had the leading edges of their wing roots modified to form a noticeable fillet, called a Strakelet. While all the B-52Hs can carry ALCMs, they do not require the strakelets because that model can be identified by other means.

Other stand-off weapons carried by modified B-52s are up to three 2,000 lb CRU anti-shipping glide bombs and from eight to twelve McDonnell-Douglas AGM-840 Harpoon anti-ship missiles. Since 1977 B-52Ds have also been equipped for mine-laying operations, carrying up to forty-three MK 40 mines or eighteen MK 60 mines.

B-52 CAMOUFLAGE – When the Vietnam war began in 1963, the USAF re-adopted camouflage for its combat aeroplanes. This was not a re-adoption of the all-olive-drab top and sides as used in the Second World War, but was based on the British Sand and Spinach of early in the Second World War, with irregular areas of tan, plus two shades of green, on top and side surfaces. Because of their nuclear capability, the B-52s retained their white undersides instead of adopting the new grey undercolour. When the B-52s were put in action over Vietnam on non-nuclear missions, the white undersides were painted black and a new 'South East Asia' camouflage

pattern with darker shades of tan and green replaced the original camouflage colouring. Early B-52F operations over Vietnam, however, involved uncamouflaged aeroplanes with white undersides. The undersides were painted black while the aeroplanes were at their combat bases.

B-52s OVER VIETNAM

The only offensive action taken by the B-52 was during the Vietnam war of 1964–75, with the period of B-52 participation from June 18, 1965, to August 15, 1973.

Operations started after two wings of B-52Fs were deployed to Andersen AFB on the island of Guam. The B-52s were refuelled over the South China Sea on the way to the target by Boeing KC-135As flying from Kadina Air Base on the island of Okinawa. A typical B-52 mission from Guam took approximately 13½ hr.

Although the bombing was mostly from high altitude – 30,000 ft and above – it was not strategic bombing in the World War II sense. Mostly, the strikes were tactical – in support of ground operations against the Viet Cong. Accuracy was phenomenal – the B-52s were able to bomb enemy concentrations by radar to within a few hundred yards of Allied troops. Area bombing of large jungle areas did much to demoralize VC forces and destroy dispersal buildings and supplies. Not until late in the war were the

A camouflaged 'Big Belly' B-52D simultaneously dropping a train of 500 lb iron bombs from the bomb-bay and wing pylons over Vietnam. (*USAF Photo*)

Not a victim of enemy action. After losing its vertical tail in severe turbulence, this B-52H was able to make a safe landing. (*US Air Force Photo*)

B-52s used for true strategic bombing, the destruction of the enemy's production capability.

In April 1967 bombing routes were shortened when some B-52 operations were based at U-Tapao, Thailand. This reduced average mission time to about four hours and eliminated the need for inflight refuelling. This base also served as a refuge for B-52s damaged over VC territory that could not return to Guam.

In 1966, the modified 'Big Belly' B-52Ds began to replace the B-52Fs, and were later supplemented by B-52Gs. At most, 200 B-52s were stationed outside the United States for action against the VC. The largest force deployed was 117 over Hanoi, North Vietnam, on December 26, 1972.

Fighter opposition to the B-52s was negligible, but the B-52s were the first high-altitude bombers to encounter surface-to-air missiles (SAMs). This was in September 1967, at an altitude of 38,000 ft, the highest effective anti-aircraft defence established to that time. Usually, on-board radar could detect incoming missiles, after which they could be seen visually, and evasive action taken. Some hits were scored, but the B-52s managed to land safely. Altogether, fifteen B-52s were lost to enemy action, but more were lost in routine operational accidents, including inflight collisions. Altogether, B-52s flew 126,615 sorties in Vietnam.

Upgrading of the B-52 fleet is a continuous operation. Two new programmes initiated in 1988 are the incorporation of an Integrated Conventional Stores Management System (ICSMS) that standardizes the connections between the aeroplane and the weapon system, and installation of an Integrated Global Positioning System (GPS), a highly accurate navigational system that uses satellites to locate the aeroplane within three metres in three-dimensional global position ordinates.

Further, approval has been granted by the Joint Chiefs of Staff for the Air Force to modify the entire B-52G fleet to conventional long-range bombers carrying stand-off weapons under a five-year programme.

Chapter 12

THE JET TRANSPORT REVOLUTION

When jet engines (turbojets) replaced piston (reciprocating) types in military aircraft after World War II, first in fighters and then in bombers, it became obvious that these power plants and the associated aerodynamic and structural changes that they had forced on aircraft designs would soon be applied to commercial transport aircraft. The pioneering efforts in this field were not made in the United States, however. The first jet transport was the four-engined de Havilland 106 Comet, which was designed structurally and aerodynamically to take maximum advantage of the characteristics of the available jet engines. The Comet made its first flight in 1949 and went into service in May 1952 to inaugurate the jet age of commercial aviation. The second jet transport was the C-102, built by the Canadian subsidiary of the British A V Roe and Company (Avro), and was a less sophisticated straight-wing design that could be regarded as a conventional propeller-driven transport with external jets substituted directly for the piston engines. Only a prototype of the Avro was built while the slightly sweptwing Comet won airline acceptance and sizeable production orders.

Strangely, since jet propulsion was associated with high speed, the first US jet transport to fly was converted from a glider, a traditionally slow design. The Air Force installed Boeing B-47 inboard jet pods on an all-

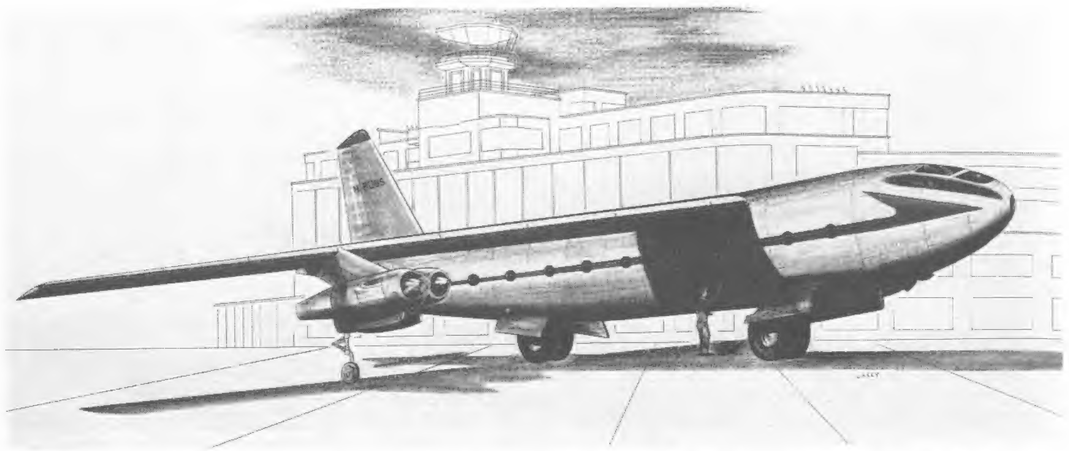
The four models of the Boeing Jetliner family in production between 1970 and 1980. From left to right: 747, 707, 727, and 737. Production of the 707 ended in 1980 after 22 years and 727 production ended in 1984 after 21 years. (*Boeing Photo P-45197*)

The first United States jet transport was the surprising combination of an assault glider and jet-bomber engines. The all-metal Chase G-20 was fitted with the inboard jet pods of a Boeing B-47 and redesignated XC-123A. (*Photo by Edgar Deigan*)

metal Chase G-20 assault glider and redesignated the machine as XC-123A. The jets were unsuited to the arrangement, intended initially to give mobility to a low-speed short-range aircraft. Piston engines were much more suitable, and the piston version was put into large-scale production as the C-123B, an interesting example of evolution in reverse.

Boeing meanwhile had been conducting studies on improved versions of the Model 367, then in production for the Air Force as the C-97. Government funds were not available for the building and testing of major alterations, so the Boeing studies remained in the paper and wind-tunnel model stages. It was recognized that the performance of the C-97 with the existing piston engines and the basic B-29 wing had reached its peak and the significant performance improvements could be obtained only with major power plant and aerodynamic changes. Various new wing configurations were studied for use with the existing fuselage, new power plants including propeller-turbines and turbojects were investigated, and finally new fuselages were considered that were more compatible with the swept wings and podded jet engines offering the optimum wing/power plant combination. Separate investigations conducted simultaneously in the field of commercial jet transports started with variants of the B-47 and reached the point where publicity releases were actually made showing artists' conceptions of jet transports with the distinctive tandem undercarriage and other trademarks of the B-47. The Boeing jet transport prototype finally emerged through the C-97 development line. By the time the basic Model 367 reached the 80th study configuration, it bore no resemblance whatever to the original C-97/Stratofreighter airframe even though the original model number had been retained.

The company believed that the Model 367–80 would be superior to any other jet transport in existence or planned and was so confident that its performance would result in sizeable orders that the board of directors authorized the expenditure of $16,000,000 in company funds for the development of an American jet transport prototype. The model number 367



Early thinking in the development of a Boeing jet transport was based on the configuration of the high-speed B-47 bomber then in production. (*Boeing Photo 111126*)

had been assigned to the C-97, in the sequence of model development dating back to 1916, when the design was started in 1942. By 1951, the Boeing model numbers had been divided into large blocks among the various product lines of the company, so the number assigned to the anticipated production versions of the new jet was in the 700 block, with the number 707 being chosen. For engineering and shop purposes, however, the 367–80 designation was retained for the prototype. This provided a convenient piece of camouflage for Boeing's jet transport plans, which of necessity were a company secret at the time. Since the names and numbers of new projects had a way of spreading through the industry, other manufacturers and the press, hearing the designation of the new project, were expected to assume that only an improved C-97 was being built. When the new project was finally made public, all publicity referred to it as the Model 707. The 367–80 was not mentioned but was the one used by all Boeing and FAA personnel and on paperwork associated with the building

The Boeing Model 367-80 shows off the 35-degree swept wing and the four podded jet engines with which it revolutionized the air transport industry. (*Boeing Photo P-17238*)

and testing of the prototype. Because of this wide company and government use, the designation 367–80 soon became public property and a source of confusion when used interchangeably with 707. The jet transport was originally given the name Jet Stratoliner by Boeing, but 707 seemed to be more acceptable to the public and subsequent company and airline advertising was directed along that line. As the additional jet transport models appeared, all were advertised collectively as Boeing jetliners.

With the introduction of its prototype jet transport in 1954, Boeing wrought a major technological revolution comparable to those achieved by the Model 247, the B-17 and the XB-47. Because of the 35-degree sweep to the wing, the 707 gained a performance lead over the Comet that was nearly as large as the lead that the Comet had taken over the latest piston-powered transports, most of which were basically prewar designs that had been stretched and fitted with larger engines to the limit of their growth capabilities. The 367–80 cruised at 550 mph, 100 mph more than the Comet 2 and nearly 250 mph more than the fastest of the piston-powered transports.

BUSINESS REVOLUTION

When the world's airlines finally adopted the Boeing 707 and its contemporaries and successors starting in the late 1950s, the impact on the way both the airlines and the manufacturer conducted their business underwent far greater change than did the military after the adoption of the jet bomber.

The prices of jet airliners took an even greater leap ahead of piston-engined airliner costs than the parallel performance increases. Where a Model 377 had cost approximately $1,500,000 in 1948, a new 707–100 cost $4,800,000 in 1958. It is hard to determine simple off-the-shelf prices for single aeroplanes, as had been advertised for piston airliners in earlier years, but unit prices often are quoted simply as a convenient reference.

Costs to the customer are affected by many things, one of the most obvious being the quantity of aeroplanes in the order, which reduces unit cost. However, other factors enter the picture – the amount of air and ground crew training provided by the manufacturer, the extent of customer support provided after delivery, the amount of equipment supplied by the customer, etc. Another factor is 'offset', the amount of structure or equipment that can be sub-contracted to firms in the customer's country. This applies more to military contracts, however, than civil.

All too often in recent years financial and political wheeling and dealing have won out over straight qualitative competition between relatively equal aeroplanes when a big order is in the offing. In such cases an irresistable deal for the customer will sometimes result in the order going to what might be considered the lesser aeroplane.

At first, the major appeal of the jet airliner was its greatly increased speed. Not only did the passenger reach his destination sooner, but over a given period a single aeroplane could generate more revenue simply by being able

The original Boeing 'Narrow Body' jetliners had six-abreast seating with three seats on each side of a single aisle. This is a Model 727. The later 'Wide Body' Model 747 features two aisles and maximum seating in a 3-4-3 arrangement ten abreast. (*Boeing Photo P-32011*)

to make more round trips over a given route. An unexpected benefit was further revenue from greatly decreased down time; the smoothness of jet engines greatly reduced airframe fatigue and the need for frequent overhaul and component replacement. Further, the airlines, the manufacturers, and the FAA worked out new maintenance programmes that allowed much work to be done during airline turn-around, allowing greater daily utilization of the aeroplane for still greater earnings. Current utilization rates can be as high as 14 hours a day.

A feature of the early jets largely overlooked now (1988) is the greatly increased capacity of the aeroplanes themselves. The early Boeing 707-100, with non-stop transcontinental range, seated 121 first-class passengers compared to 55 for the Boeing 377 and 69 for the Douglas DC-7B models that it replaced. Even the 'small' short-range Boeing 737-100 and the Douglas DC-9 that preceded it by two years, seat 107 and 80, respectively. All jetliners have gone through subsequent stretches of the cabin area to increase their capacity.

The use of aeroplanes for the carriage of bulk cargo also became significant during WW-II, when established passenger designs on both sides were adapted to heavy haulage by the addition of large cargo doors and reinforced cabin flooring. After the war, some major airlines began to assign their older aeroplanes to all-cargo operations, but this was a very small portion of their business. All-freight operations, both scheduled and non-scheduled, were conducted mostly by newer and smaller organizations formed after the war.

The introduction of jetliners had a great effect on the air freight industry.

This Model 707-328 with original small tail had early thrust reversers combined with sound suppressors at the rear of each engine pod. (*Boeing Photo P-23138*)

Airlines began carrying cargo in passenger jets, and the freight lines were forced to buy jets in order to remain competitive. Again, the airlines converted older jetliners to all-cargo use, but the business expanded greatly after Boeing introduced factory-new variants with cargo doors, reinforced flooring, and new cargo loading systems, the first built-for-the-purpose jet freighters. All Boeing jet airliners now have cargo-door options. Some freight-carrying aircraft are convertible in that they can be equipped to carry only freight, only passengers, or a combination of the two. Others, however, are built as dedicated freighters only, with no windows or any of the usual passenger facilities.

The point-to-point speed of jetliners used to haul cargo, a major factor in the increasing popularity of air freight operations, would be offset considerably if cargo were to be loaded by traditional methods based on truck and railway wagon loading. Taking guidance from recent marine procedures, airlines and jetliner manufacturers soon developed entirely new method of loading cargo into aeroplanes. Instead of loading a given number of boxes individually, quantities of boxes are put on flat pallets and secured by tie-downs or covered with a net. The pallet is then raised to the cargo door by external lifting equipment. In special freighter aeroplanes with large cargo doors, distribution systems with powered rollers enable a single operator to move the pallets to the desired location, where they are secured.

Related to pallets are lightweight metal containers contoured to fit the curved sides of the aeroplane cabin or cargo hold, for both upper and lower deck stowage. These are available in several standardized sizes for easy interchange between airliners. The large 40 ft by 8 ft rectangular containers used on the upper deck of Boeing 747 freighters are interchangeable with similar-sized containers used by ships, railways, and trucks.

A new phase of the all-cargo business has appeared in recent years: package express. Small items, formerly sent by special handling in small quantities, now require entire fleets of dedicated aeroplanes. At first, the

package express companies stayed with small but fast piston-engined aeroplanes, but soon stepped up to small jets. Then the package express operators bought older jet airliners being retired by the trunk airlines and finally are buying fleets of factory-new jets modified and equipped to their special requirements.

PROBLEMS

However, the transition to jets was not without significant problems. The introduction of the jet transport brought to civil aviation two of the major problems that the military had encountered earlier – stopping the heavy propellerless aircraft on the runway, and jet noise. Since the military bases generally were further from population centres, noise was not too great a community relations problem. It became so serious in commercial operations, however, that some close-in terminals such as New York's LaGuardia were barred to the first jets. Deceleration parachutes, which helped the braking problem for the military, were not considered suitable for passenger aircraft, although they were used to a limited extent. Boeing attacked both problems simultaneously, and, after several years of intensive research and test and the expenditure of nearly $15,000,000 in company funds, developed a device that fitted over the tailpipe of the jet engine to serve as a sound suppressor during take-off and a thrust reverse after landing.

While thrust reversers helped, braking of the high-speed heavy aeroplane still presented a major problem, so Boeing worked with the supplier of the wheels, brakes, and tyres to develop improved components that would meet the new requirements. Anti-skid braking systems also were developed.

In later years, new jet engines were designed to produce less noise, and 'quiet' nacelle structures were developed to permit older jet models to meet the new Federal noise limitations imposed in 1985.

Greatly increased passenger loads required extensive revision of aircraft evacuation procedures and equipment. Here are five on-board escape slides on each side of a Model 747. For overwater flights, some of these become rafts. (*Boeing Photo 83NK04500-1*)

In Quick-Change (QC) Boeing Jetliners, passenger seats are permanently affixed to floor-width pallets which can be rolled into the aeroplane and secured to the cargo fittings on the freighter floor. Twelve passenger seats occupy a single pallet on this Model 727QC. (*Boeing Photo P-39421*)

Since the jets were to operate at considerably higher altitude than piston types, the structural integrity of the pressurized cabin became a more serious problem than hitherto, particularly after some early de Havilland Comets broke up in flight due to explosive decompresssion following metal fatigue introduced by the skin flexing under continuous pressurizing/depressurizing cycles.

After the long-range Boeing 747 was introduced in the 1970s, its increased operating altitude over earlier jets moved it into an area of increased atmospheric ozone concentrations which induced severe crew and passenger discomfort. This led Boeing to pioneer in the development of cabin ozone filters, equipment that had not been needed previously. Also, long flights of up to 14 hours duration made it necessary to carry two cockpit crews, a throwback to the Model 314 flying-boat days.

The high point-to-point speed across several time zones introduced a new phenomenon to air travel – so-called 'jet lag'; passengers and crew found it hard to adjust to routine activity in the new time zone while their physical systems were still on 'home' time.

Reduced fare Air Coach travel had come into use before the introduction of jets. In this, the airline flew the coach passengers in older equipment modified with higher-density seating, reduced conveniences, and less

The main cargo decks of jet freighters are loaded by external equipment. This fork-lift holds a palletized Igloo which will occupy nearly the full width of the cabin of the Model 727QC. (*Boeing Photo P-39731*)

desirable schedules. With the wide adoption of jets, airlines put as many as three separate fare classes in the same aeroplane, with different personal services, seating density and cabin service for all three.

To relieve the boredom of long flights, the airlines adopted inflight entertainment in the form of feature films shown on cabin screens and selections of recorded music through individual headphones.

In spite of their increased size and performance, the jet airliners did not necessarily require extra cockpit crew. On the contrary, automated systems and advanced instrumentation have resulted in reduction of the cockpit crew to only two, eliminating the former separate functions of flight engineer, navigator, and radio operator.

The increase in passengers per aeroplane has necessitated major improvements in baggage loading and unloading techniques and new automated loading equipment at major airports. The need to evacuate a greater number of people under emergency conditions has resulted in a greater number of emergency exists, escape slides, and life-rafts on the aeroplane.

The 707 soon won worldwide acceptance and managed, unlike the 247, to maintain a performance advantage over the competitive designs that followed it. However, since it was basically a medium-to long-range design used initially on transatlantic routes, it was uneconomical on short inter-city routes. To meet the demand that developed in this market Boeing produced the Model 720, which had the same wing span as the smallest 707 but was

As the Overnight Package Express industry evolved, the operators moved up from small piston-engine aeroplanes to used jet airliners. Here are nine former passenger Boeing 727s converted to side-door freighters for Federal Express. (*Boeing Photo P-53369*)

shorter and lighter; it also had improved aerodynamic features that suited it to operation from airport runways considerably shorter than the two miles of concrete needed for the take-off of the heavily-loaded long-range models.

The demand for jet performance continued to work down to the lower levels of the airline business until even the regional and short-haul lines, most of which used relatively small twin-engined aircraft, were asking for jets tailored to their particular requirements. Boeing again met the demand with its third and fourth jet transport designs, the Models 727 and 737. These were both entirely new designs, and not further reductions of the basic Model 707.

A perceived requirement for a long-range large-capacity jetliner resulted in the design of the Model 747, which coined the term 'Jumbo Jet' and prompted the design of several somewhat smaller competitors. A need to replace the 707 and 727 models as their long production life ended resulted in two further Boeing jetliners, the Models 757 and 767.

The Boeing Model 727 was first produced as a passenger-only jetliner, but the final fifteen were built as dedicated freighters with side cargo doors and without windows or passenger accommodation. (*Boeing Photo*)

MARKETING PROBLEMS

Initial production of Boeing jet transports was for the US Air Force, which ordered twenty-nine KC-135A tanker-transports two months after the prototype first flew. Recognizing the financial problems that the airlines faced in switching to jets, Boeing sought to keep initial costs down by obtaining permission to lease some portions of the government-owned KC-135 tooling for 707 production and by building a standard airframe needing only minor interior and equipment alternations to meet the requirements of the different airlines, as had been done with the model 377 Stratocruiser. However, this scheme was not carried through.

While the inevitable replacement of existing transports with sweptwing jets became obvious upon the debut of the 367–80/707, the financial problem of large-scale replacement was a formidable obstacle which the airlines could not overcome quickly. This resulted in a stand-off for a while – Boeing could not produce the 707 without firm orders and the airlines could not order until the finance could be arranged and a reasonable return had been earned on the newest piston-engined transports then in service.

This forced Boeing and other jetliner manufacturers into a situation that continues to this day – the need to accept an airline's fleet of obsolescent models as part payment on new jets. By 1982, this problem had reached such proportions at Boeing that a new division of the Company, Used Aircraft & Sales, was set up under a vice-president to handle the resale of, and customer support for, such acquired airliners, many of them non-Boeing.

In the absence of trade-ins, some other airlines had different financing problems. They could not afford to buy needed new jets outright, so arranged to lease them, either directly from Boeing, through brokers, or from organizations established specifically to buy jets under their own name and then lease them to airlines.

This led to some odd markings, such as a European airliner carrying US civil registration because it is owned by a US firm. Conversely, some airliners in United States service carry European registrations as a result of being leased by the US line from a European operator in order to meet a short-term equipment need or for early use of a needed airliner before purchase from the previous owner.

Boeing also on occasion found itself stuck with brand-new models that could not be delivered because the customer could not pay for them. These then sat on the flight line or at a satellite storage facility and were known as 'white tails' because they carried no registrations or airline markings.

JETLINER TRAINING AND MAINTENANCE

When jets first entered airline service, aircrews were trained in the traditional way – by receiving instruction in the actual aircraft. Because of all the differences in systems, power plant, and flight characteristics, transition to a jet transport was more involved than simply stepping up from one piston model to another, as from a Douglas DC-6 to a DC-7.

The increased number of flying hours required, plus the high hourly operating cost of the aeroplane, resulted in a unique situation in some airlines; they did not consult their most senior pilots, those who would logically put these models into service, because they were too close to their retirement dates to justify the cost of training them for a relatively short period of subsequent service.

Training costs have been greatly reduced in recent years by the introduction of three-axis flight simulators that can be directed by an on-board instructor to duplicate any flight condition to test pilot reaction to unusual situations without risk to an actual aircraft or the cost of operating it. The trainees are completely enclosed in the simulator, and see computer-generated views of representative scenery and even specific airports and the adjacent terrain through the windows. Some of the simulators are realistic to such a fine degree of detail that the sensation of passing over the tar strips on the runway or taxiways is felt during the taxi-ing.

So thorough has simulator training become that the FAA now accepts crew time in the simulator as the equivalent of actual flight time for the issue of pilot type and model ratings.

To obtain higher daily utilization of the jet transport, it became necessary to revise traditional methods of performing periodic maintenance. Instead of taking the aeroplane out of service for several days at a time, new programmes were developed in which continuous maintenance is performed during aeroplane stop-overs and turn-around periods. It is still necessary, however, to take the aeroplane out of service for major overhaul.

Under this system, as noted above, utilization of some Boeing jetliners has reached a level of 14 hours of operation in a single day.

TWIN-ENGINE EXTENDED-RANGE OPERATION

Since the piston-engine days, government regulatory agencies in major aircraft operating countries have restricted twin-engined airliners to routes along which an 'adequate' airport for unscheduled landings was always within one hour's flying time with one engine inoperative.

Following introduction of the twinjet Boeing 757 and 767, with their great range plus the reliability of the modern jet engine, Boeing sought a revision of the long-established rule. Eventually this was granted; the Boeings and some other manufacturers' twin-engined models were approved for routes up to two hours away from an adequate airport.

This approval required certain equipment additions to the aeroplanes, such as triple independent sources of AC power, adequate equipment cooling, increased fuel capacity, fire-suppression in cargo holds, and for the particular engine model to be used, 250,000 engine-hours of operation in the world fleet.

Even after the aeroplane is approved for Extended Range Operation (EROPS) or Extended Range Twin Operations (ETOPS), it cannot simply be put into such service by any customer. The use of EROPS/ETOPS involves particular requirements on the part of the operator, too. In general,

There is much interchange of equipment among the jet-equipped airlines. This Boeing 707-436 was leased by owner BOAC to Nigeria Airways, flew under British registration, and carried the names of both airlines. (*Boeing Photo P-34240*)

The twinjet Boeing 767 has been approved for Extended Range Operation and is now a regular North Atlantic aeroplane. (*Boeing Photo*)

to obtain approval for EROPS/ETOPS operation with approved aircraft, the airline must have at least one year's experience with the particular aeroplane model, must meet certain requirements as to aircrew experience, company maintenance programme, propulsion system reliability record, despatch and flight planning procedures, etc.

All three Boeing twin-engined jetliners, starting with the Model 767, are approved for EROPS/ETOPS when appropriately modified. These are identified by an ER suffix to the model designation, as 767-200ER, for advertising purposes but not always in production records or the type of listing used by this book.

At 1988 prices, the EROPS/ETOPS modification can add $3 to $5 million to the cost of the aeroplane, depending on the model.

BOEING JETLINER DESIGNATIONS

From the Model 707 on, Boeing has used a revised designation system to identify jetliner variants as to structure, power plant, and customer. In the case of the 707, for example, the initial model was designated 707-100. Subsequent power plant and structural changes resulted in the 707-200 series, 707-300 series, etc. The Model 720, 727, 747, and on demonstrate minor exceptions to this rule, as explained in their respective chapters.

Identification of a variant by suffix number, actually series number but sometimes called dash number, is not consistent. The designation 707-400 applies to long-range 707s, essentially -300s, which use British Rolls-Royce engines instead of US-made Pratt & Whitneys. On the other hand, a change from turbojets to later turbofans, plus some structural changes, resulted in the addition of a suffix letter B, as 707-300B, either to aircraft built with these engines or those converted from earlier variants, as 720-023 to 720-023B. However, the letter B has a different meaning when used with the 747 designation.

Changes within the series, like the addition of cargo doors and reinforced flooring, resulted in 707-300C, while a 'Quick-Change' model that could be changed from passenger to freight configuration became the 727-100QC, etc. These identifications are detailed fully in the individual aeroplane descriptions in subsequent chapters.

Finally, every original customer for a new Boeing jetliner, identified by Boeing as a 'first tier' customer, is given a modified series number, or number-letter combination, which is added to the basic aeroplane designation. The first customer for the 707-100 (called 707-120 by Boeing) was Pan American World Airways, so its 707-100s became 707-121s. Similarly, American Airlines' 707-100s became 707-123 and were later converted to 707-123B. TWA ordered 707-131s, etc.

These series numbers are assigned permanently to the aeroplanes of the initially-identified customers and very rarely is the same number assigned to another customer, and then usually in case of close ties between the customer, or sale of an undelivered aeroplane to another customer, etc. There were exceptions, however, such as TWA ordering eighteen 707-331s but releasing six to Pan American before delivery, which used them as -331 without designation or equipment changes.

In another case, it was desirable to change the series number because of a significant change to the aeroplane. Flying Tigers bought some 747-123s from American Airlines and had two of them modified to side-door freighters. The airline requested that these aeroplanes be redesignated 747-149, since it already had 747-249s in its fleet. After much discussion Boeing decided that this would cause too much complication of existing records, and should not be done; the aeroplanes remained 747-123s in spite of their non-conformity to that configuration.

Aerolineas Argentinas ordered five 707-387Bs, but one was diverted from the order to completion as a special VIP aeroplane for the President of

Argentina.The extensive changes justified a new series number, 3F3B, and even an entirely new maintenance manual. However, the President died before the aeroplane was finished and his successor did not want it, so it was completed as a 707-387B and delivered to the airline as such.

The series number sequences are not complete within each model (eg 707-121, -122, -123, etc). The number 22 was assigned to United Air Lines for a 707-100 that the airline declined to buy, so there never was a 707-122. However, United subsequently ordered 720-022, 727-22, 737-222, 747-22, and 767-222 models, and now 757-222.

When the number of customers reached 100 after some backing up before -121, the system was revised to use a letter-number suffix to the series number, as 707-3F9C for a 707-300 cargo version for Cameroon (F9), a convertible cargo-aircraft.

The series number assigned to the first-tier customer remains with the aeroplane regardless of subsequent changes of ownership, even by other first-tier customers using the same model. This confuses the identification problem when working backward from airline markings. As an example, one US airline, Piedmont, is a first-tier customer, with 737-201s. It also has second-hand, as second-tier, 737s built originally for eight other first-tier customers, giving a total of nine different sub-designations in a fleet of 100 identically-painted 737s.

The original owner of a Boeing jetliner cannot always be determined from the series number of the aeroplane. Some of the organizations which buy aeroplanes to lease to airlines, rather than operating themselves, may buy a quantity of a particular model under a series number assigned to them by Boeing and then lease them to various airlines under that same series number. Often, however, the leased airliners are delivered straight from the production line to the leasing airline, equipped to that airline's standards and carrying its livery.

In other cases, the leasing organization may buy a jetliner already ordered, but not paid for, by an airline and then lease that aeroplane to the same airline under the original series number. In such cases, the airline technically becomes a second-tier operator of the same aeroplane series that it has as a first-tier operator.

AGEING JETLINERS

In the past, older airliners in service were outclassed by newer models and were replaced after a few thousand hours of flying time. Since the Boeing 707 went into service with a cruising speed of Mach ·85, just below the speed of sound, no newer models other than the supersonic Concorde have significantly surpassed it in speed, thereby eliminating this particular reason for replacement.

Further, the earning power of the jetliners was so great and their replacement cost so high, that the major airlines kept them in service for many years more than their piston-powered predecessors. The initial design life of the early Boeing jetliners was 30,000 flying hours, which was

generally the industry standard at the time. The smoothness of jet operations, plus greatly improved reliability and easier maintenance, soon made it evident that this expectancy could be exceeded easily, and Boeing inaugurated inspection and maintenance procedures specifically aimed at increasing airframe life to 60,000 flying hours. Recent programmes have resulted in expectancies of 80,000 hours or more, a total reached by few aeroplanes so far. The world record for accumulated flight time, 90,917 hours, at March 12, 1989, belongs to a Douglas DC-3 which had been operating continuously since 1937 and is still in scheduled service. However, the greater daily utilization of jets built 25 years later may enable some to reach and surpass this record.

In keeping track of all Boeing jetliners in service, the Company compiles detailed statistics on every aeroplane. Periodic summaries are published that indicate two milestones of aeroplane use – the total number of flying hours and the number of landings. The ratio of one to the other is a good reflection of aeroplane usage. A long-range jetliner may average 10 or more hours for each landing while one with several landings per hour may indicate a training operation and a ratio of one landing per hour a short-range airline operation.

TECHNICAL DATA CHANGES

The different technology and operating procedures of jet aircraft have an effect on the way certain data are presented in the jet aeroplane descriptions in this book compared to the data for the earlier piston-powered aeroplanes.

Weight figures are no longer given simply as 'empty weight' and 'gross weight' either for customer use or publication in reference books such as this. The former empty weight figure has been replaced by two: 'zero fuel weight', meaning the fully-equipped aeroplanes less fuel and passengers/crew/cargo, and as a lower figure, airline 'operating empty weight' (OEW), meaning the aeroplane with normal airline equipment installed but no fuel, crew, or payload. For the Model 707-300, these figures are:

Zero fuel weight	190,000 lb
Airline OEW:	134,500 lb

The old gross weight figure has been replaced by three: 'maximum taxi weight', 'take-off weight', and 'maximum landing weight'. The first is in recognition of the present situation at major air terminals, where the aeroplane may spend a long time on the ground with engines running and consuming great quantities of fuel before receiving take-off clearance. The aeroplane is permitted to taxi at a weight significantly greater than that at which it is allowed to fly.

Further, the aeroplane must reduce its weight greatly before being allowed to land in order to reduce the stress of landing on the airframe. This is not a problem at the end of a normal scheduled airline flight, but requires either the dumping of fuel or remaining airborne until the fuel weight is reduced if an emergency requiring a return to the airport of departure or an

alternative must be made soon after take-off. This reduced landing weight requirement has existed since the 1930s, but before the jets the figures were not published with the other standard weight data.

Examples of these three weights for the Model 707-300 are:

Maximum taxi weight:	316,000 lb
Take-off weight:	312,000 lb
Landing weight:	207,000 lb

The maximum and minimum weight figures given in the technical data presentations for Boeing jetliners in this book are the take-off weight and the operating empty weight.

Airspeed figures are given in statute miles per hour or, following the military preference, in knots, a knot being one nautical mile (6,080 feet) per hour. Here, available speed figures are given in statute miles per hour.

At the high end of the speed range, however, jet pilots fly by reference to the Machmeter, which gives the aeroplane's speed as a percentage of Mach 1, the speed of sound, rather than a specific airspeed indicator reading such as 625 mph. The speed of sound varies with temperature and altitude, but is generally considered to be 750 mph at sea level at a temperature of 70°F. Figures presented for range are the distance that the aeroplane can travel in a straight line in zero-wind conditions with a full payload and the allowable fuel for the gross weight with no reserve. Current requirements for reserve fuel and possible detours to alternate destination airports greatly reduce the actual operating range of the aeroplane.

The many combintions of aeroplane configuration, payload fuel capacity and power plant make it impossible to tabulate all the performance figures for the combinations. For example, there are nine different size/weight combinations for the Model 767 and seven variations among three alternative power plants. Performance figures in the tables for jet airliners are for the particular gross weight shown and for the first power plant listed when alternatives also are listed.

Chapter 13

MODELS 367-80, 707, and 720

The Boeing jet transport prototype, the Model 367-80, is described in this chapter with its two immediate civil derivatives, Models 707 and 720. Military variants and conversions of the 707 are described in Chapter 14. The military Model 717, also derived from the 367-80 and ordered by the US Air Force as the KC-135, is described in Chapter 15.

MODEL 367-80 – By 1951, studies to improve the basic Model 367 (C-97) had progressed through so many major changes that an entirely new design had been developed which bore no resemblance whatever to the original. The dual function of a tanker-transport was kept in mind, however. Unable to win Air Force orders for the new model from paper studies and convinced that both a military and commercial market for a pure jet transport would appear after a suitable aeroplane was demonstrated, Boeing decided to develop and build a prototype at its own expense and initiated the project on May 20, 1952.

The Boeing Renton plant — home of the Jetliners. The buildings by the lake shore are the original WW-II installations. (*Boeing Photo 6A-57978*)

Roll-out of the revolutionary Model 367-80, May 14, 1954. (*Boeing Photo P-14306*)

Aerodynamically, the 367-80 was a logical combination of the proven aerodynamic and structural features of the B-47 and B-52 combined with the cabin capacity of the Model 367 and other conventional transports. The wing used the 35-degree sweep of the military jets, but was a much more rigid design with pronounced dihedral built in. Dihedral was also used in the horizontal tail and the wing flaps were divided opposite the inboard nacelles to avoid interference with the jet exhaust. Two sets of ailerons were used, small ones mounted inboard between the flaps for cruising flight and larger ones in the conventional wingtip location which were to be used only when the flaps were lowered for take-off and landing. Additional aileron action was obtained by the use of spoilers, which operate differentially as ailerons or simultaneously as air brakes. The basic fuselage structure used the figure 8 pattern of the C-97 and was the same width, 132 in, but with the pronounced crease at the joint smoothed out. The main landing gear trucks, each with four wheels, retracted inward into the bottom of the fuselage. Four Pratt & Whitney JT3 engines, commercial equivalents of the 10,000 lb thrust J57s used on the B-52, were installed in single pods under the wing. Consideration had been given to pairing the engines as in the B-52, but the safety considerations of commercial operations ruled this out, since failure of one engine of a pair was likely to endanger the other and result in an unacceptable 50% power failure.

The single Model 367-80 aeroplane was built strictly as an experimental prototype and was never intended to enter service with the following production models as was the usual practice, hence many refinements such as full rows of passenger windows, extensive lavatory and galley facilities, etc, could be dispensed with. Few cabin windows were used and two cargo doors were installed on the port side of the fuselage, one at each end of the 90 ft main cabin.

Following its first flight on July 15, 1954, the 367-80 was evaluated by the Air Force both as a pure transport and as a tanker with an improved Boeing

The double ailerons, flaps, and spoilers of the Model 367-80. The protrusions on the forward wing surface are vortex generators. (*Boeing Photo P-15911*)

flying boom installed. This demonstration of jet transport capability with an actual flying prototype instead of a paper study resulted in an order for military KC-135A jet tanker-transports (Boeing Model 717) being placed in September 1954. Attention was then concentrated on selling commercial versions to the airlines under the designation of 707. The name Jet Stratoliner was used in the initial advertising campaign and was applied to the Model 707-120, but was later dropped in favour of straight numerical designation of the various configurations, or the name 707 Intercontinental for the long-range models.

With production of military KC-135s and commercial 707s under way, the 367-80 continued to serve as a guinea pig for testing all manner of new equipment and even major aerodynamic features to be used on the later models. Special piloting techniques were required when a larger Pratt & Whitney JT4 engine was installed in the left inboard pod. This engine had

First flight of the Model 367-80 – July 15, 1954. (*Boeing Photo P-14435*)

Simulated refuelling of a B-52B with an improved Boeing Flying Boom installed on the Model 367-80, 1955. (*Boeing Photo P-15746*)

different acceleration characteristics as well as greatly increased power, so the throttles had to be advanced at different rates for the different engines. At one time, three different engine models were in use simultaneously in the four nacelles. Later, a fifth engine was temporarily installed on the port side of the fuselage to test the planned installation for the Model 727. Since the 727 was to have a T-tail placed well above the exhaust of the side-mounted jets, the engine installed on the -80 had a dog-leg exhaust pipe to direct the jet wake over the horizontal tail. The eventual use of JT3D turbofans resulted in the designation of Model 367-80B for the aeroplane.

The wings underwent considerable modification during the development of later models; planform, thickness, and aerofoil being altered by building a sleeve to fit over the inboard end of the basic wing. This increased the wing area by 421 sq ft while new wingtips brought the span up to that of the production 707.

Model 367-80 with nose modified for AN/AMQ-15 weather reconnaissance radar, 1959. Outboard engines are JT-3, No. 2 is J75, No. 3 is J57. (*Boeing Photo P-23109*)

Model 367-80 with fifth engine installed temporarily for testing of Model 727 features in 1960. Note altered shape of wing at centre section. (*Boeing Photo P-27317*)

Some experimental flap installations had interesting side effects. Many tests were conducted with solid metal units that were merely bolted on in the extended position. Since these could not be retracted in flight, the operating speed of the aeroplane was very low, in some cases little above the normal landing speed. This meant that the conventional Sabre fighters, leased by Boeing from the Royal Canadian Air Force for use as chase aircraft to observe the actions of the test aeroplane from a close-in flight position, could not be used. Boeing had to lease commercial light twin-engine designs to follow the now super-slow jet transport through its test routines. The aeroplane was also used for tests by the National Aeronautics and Space Administration (NASA) with blown flaps, which were conventional trailing-edge type but which could be extended to a full 90-degree position with high-velocity air bled from the jet engines being blown over them.

In support of a research programme for a heavy military transport, the 367-80B was temporarily fitted with a non-retractable 'high flotation' undercarriage with four additional wheels with low-pressure tyres on the

Boeing Jet Transport prototype was redesignated 367-80B after installation of JT3D turbofans. Note leading-edge flaps and revised trailing-edge flaps. (*Boeing Photo P-29065*)

Model 367-80B fitted in 1963 with enlarged Model 707-320C horizontal tail and enlarged trailing-edge flaps that are 'blown' by high-pressure air bled from the jet engines. Inverted Krueger flaps were fitted to the tailplane. (*Boeing Photo P-35359*)

main undercarriage and two additional wheels on the nose unit to permit operation from soft and unprepared surfaces. This test undercarriage was locked in the down position because there was no room in the wing to retract the additional wheels.

In 1972 the 367-80 was retired and donated to the National Air and Space Museum of the Smithsonian Institution, which had designated it as one of the twelve most significant aeroplane designs of all time.

TECHNICAL DATA - MODEL 367-80 (1954)

Type:	Jet transport prototype
Accommodation:	3 crew, no standard passenger accommodation in cabin
Power plant:	Pratt & Whitney JT3 10,000 lb thrust
Span:	129 ft 8 in
Length:	127 ft 10 in
Height:	38 ft
Wing area:	2,400 sq ft
Empty weight:	92,120 lb
Gross weight:	190,000 lb
Max speed:	582 mph at 120,000 lb at 25,000 ft
Cruising speed:	550 mph
Service ceiling:	43,000 ft
Climb:	2,500 ft/min at sea level
Range:	3,530 miles with reserves
C/n:	17158
Registration:	N70700

Although they carry different model numbers, the Boeing 707 and 720 are very closely related and were built on the same production line. Boeing c/ns and Production Line numbers for the 720s are combined with the 707s in Boeing statistical and sales records, so the two models are described together in this chapter.

To test the ability of a projected military transport design to operate on soft terrain, the 367-80 was fitted with ten additional wheels on a non-retractable undercarriage and flown from a dry lake bed. (*Boeing Photo P-36715*)

MODEL 707 – As initially offered to the airlines in the form of the Model 367-80, the derivative 707 had a notable shortcoming of the Model 247 – the cabin was considered by many to be too small. Even the Air Force insisted on a 12-in wider cabin for the KC-135A tanker/transport. Believing that this wider cabin would satisfy the airlines, Boeing sought to obtain cost-savings for the airlines by obtaining Air Force permission to use some of the KC-135A tooling for 707 production, but the airlines wanted still larger cabins. After losing an expected 40-aircraft order to Douglas, whose very similar DC-8 was still on paper and could therefore be altered easily, Boeing increased the cabin width by another four inches and lengthened it by 10 ft to produce the initial Model 707-100 and received its first order on October 13, 1955.

At first, passenger accommodation was based on existing airline practice, the most modern aircraft being used for first-class travel while tourist class passengers were flown over the same route in older and slower equipment. By the time the 707 was ready to enter service, however, airline practice had changed and two classes (sometimes three) were carried in separate areas of the same aeroplane. To accommodate varying passenger-class ratios, section-dividing bulkheads were made movable so that the seating could be varied. The first-class passengers have lower density seating, more elaborate meals, and more personal attention from the flight attendants. The first-class passengers ride in the front of the aeroplane and tourist or economy class in the rear.

Wing detail differed from the prototype in that a retractable Krueger leading-edge flap, 14 in by 12 ft, was installed inboard of the outboard engine pods to extend automatically when the main flaps are lowered 9½ degrees. In 1959, modifications were worked out for the vertical tail surfaces to improve directional stability. The height of the vertical fin was increased and fixed area was added above the rudder. A separate small fin, sometimes called a ventral fin and sometimes an underfin, was added to the bottom of the fuselage. This underfin served as a bumper to protect the aft fuselage and act as a warning device in case the take-off was made with an excessive

nose-high attitude which would decrease lift. The pilot can feel the light initial contact of fin and runway and correct the attitude of the aeroplane. Most but not all 707 series aircraft delivered before this change were eventually modified to include it. All subsequent 707 models were delivered with the higher vertical tail but not all had the underfin.

A distinctive feature of the 707 and KC-135 series was the installation of a boom-like antenna that pointed forward from the top of the vertical fin. At first, this was a convenient guide for those unskilled in aircraft recognition, enabling them to distinguish the Boeing from the very similar Douglas DC-8 and Convair 880/990. Unfortunately, several airlines operating the later and similar-looking Boeing Model 720 did not use this type of antenna.

Certain features of the 707-100 became standard for most subsequent Boeing jetliners – passenger entry doors on the port side at each end of the upper-deck cabin and lower-deck cargo hatches ahead of and aft of the wing on the starboard side. The original airline 707s did not have the upper-deck cargo doors of the 367-80, but cargo doors ahead of the wing were provided on later C-series 707s. Altogether, 916 civil 707s were delivered from August 1958 to April 1982. Although some of these were delivered to various military forces, they are considered to be commercially-configured aeroplanes. The basic 707-300 airframe was still in production in 1988 and is expected to continue into the early 1990s for a single-model production life of 35 years, a period totally unforeseen when the 707 was first offered to the market at unit prices of approximately $4·3 million. By 1978 the price of the 707-300C model had increased to approximately $15 million.

The long production life of the 707, far greater than that of any previous transport aeroplane, allowed later production versions to incorporate new technical features of later Boeing models that were in production concurrently with the 707.

The 707 also enjoyed a long and prosperous airline life. Two of the original airline customers, Pan American and TWA, both retired their last 707s in October 1983, after nearly 25 years of service. Commercial versions remained in production through 1979, the last being delivered in April 1982, after use as a power plant test aeroplane (*see* 707-700).

By mid-1965, when deliveries passed the 430 mark, the 707 became the world's best-selling civil transport aeroplane to that time, and held that record until it was surpassed by Boeing's Model 727 in 1973. This statement would seem to be contradicted by the world-wide use of 1,470 commercial Douglas DC-3 propeller transports officially recorded in 1971. However, only 430 DC-3s were delivered as civil airliners before the Japanese attack on Pearl Harbor. The rest of the 10,655 built by Douglas were for military use. The majority of the postwar DC-3 transports were former US Army C-47s (US Navy R4D, Royal Air Force Dakota) converted to civil configuration and operated under the prewar DC-3 Approved Type Certificates.

The departure of the 707 from airline service was hastened by new anti-noise legislation that became effective at the end of 1985. To continue operations, 707s and other jetliners using the Pratt & Whitney JT3 and JT4,

or equivalent jet engines, had to undergo costly nacelle modifications that reduced the objectionable noise to acceptable levels. This could be accomplished by the installation of 'hush kits', costing some $2 million per aeroplane, developed by various specialist organizations. Needless to say, such mandatory modifications drove the price of the older 707-100s to as low as $600,000. Still, the modification cost was far less than the cost of a new jetliner, and modified 707-300Cs were worth between $4·5 and $7 million in 1986.

Operators of 707s registered in countries not having the anti-noise requirement had to obtain special permission to fly their 707s into the United States and were limited to landings and departures only at coastal airports. At the end of 1988, 236 Model 707s were still in airline service throughout the world. At September 30, 1988, the total number of Model 707s ordered stood at 845 of which 827 had been delivered. Of this total 725 were commercial aircraft and all these had been delivered. By series these were: -100 and -100B, 138; -200, 5; -300, 545; and -400, 37. By the end of March 1988 the high-time Model 707 had flown 79,989 hr and the greatest number of landings achieved by a 707 was 35,958.

Note: Because of the greater numbers involved, it is not practical to list all first-tier customers under the model descriptions of each Boeing jetliner, as has been done in the case of the piston-engined transports listed earlier in this book. Instead, the jetliners are listed in Appendix VIII, and tabulated by customer, dash number, registration and c/n.

• 707-000 – This is not an actual Model 707 series designation but a convenient reference to Model 720 aircraft by some airlines that prefer to identify their 720s with the widely-publicized 707 rather than make a distinction between the two very similar looking models in their advertising campaigns. No conflict of designation is involved. A 720-023 can safely be called a 707-023 since all 707 series suffix numbers are above 120.

• 707-100 – Initial production version of the Model 367-80 prototype. Boeing records and publicity refer to this as the Model 707-120, but FAA

Model 707-123 for American Airlines, with the original small vertical tail that was standard on early 707s. (*Boeing Photo P-20587*)

records and the type certificate identify it as Model 707-100. Dimensions are slightly enlarged over the prototype and power and weight are increased. Passenger accommodation ranges from 124 first-class to 179 for all-tourist seating. First flight of the 707-100 series was on December 20, 1957. The certification programme used the first three aircraft. ATC 4A-21 was issued on September 18, 1958, and commercial operations began on October 26, 1958. Approximate cost of a 707-100 was $5,500,000.

The first 707s were designed as medium- to long-range transports, but were not intended for very long-range transoceanic operations. However, they were capable of transatlantic service, and the first ones were put on this route for competitive reasons, using their full fuel capacity with slightly reduced payload.

The first 707 order was placed by Pan American World Airways (PAA) for six that were given the designation of 707-121. Since this airline was the first to use the 707, it wanted to get the maximum possible publicity from the new model and obtained a special block of registration numbers from the FAA that started with the aeroplane model number and ended with the initials of the airline. Since three aeroplanes were to be used in the certification programme, two of them in Boeing markings, PAA specified that the first to fly with the airline markings should carry the registration N707PA. Since this machine was the second of the series, an exchange of registrations was made with the first. When putting its first 707s in service, PAA complied with a precautionary FAA requirement that the first revenue flights of the 707s be without passengers. The airline took delivery from the factory very early in the morning, landing at Bermuda or at Miami, Florida, at the end of a shakedown flight. Cargo was then loaded for New York. After unloading and refuelling at Idlewild (now Kennedy) International Airport, the aeroplane was loaded with transatlantic passengers and took off for

One of a pair of orphan jet liners – 707-139s, undeliverable to original customer CUBANA, were leased to Western Airlines, eventually sold to Pan American. (*Boeing Photo P-24604*)

Europe on the evening of the same day that it had left the factory. All but N709PA later were converted to 707-121Bs with JT3D engines.

TECHNICAL DATA – MODEL 707-100

Type:	Transport
Accommodation:	Up to 179 passengers
Power plant:	Pratt & Whitney JT3C-6 12,500 lb thrust
Fuel:	13,478 US gal
Span:	130 ft 10 in
Length:	144 ft 6 in
Height:	38 ft 8 in
Wing area:	2,433 sq ft
Empty weight:	118,000 lb
Gross weight:	257,000 lb
Max speed:	623 mph
Cruising speed:	571 mph at 25,000 ft
Service ceiling:	37,500 ft
Climb:	2,400 ft/min at sea level
Range:	3,075 miles with maximum payload, no fuel reserves

• SHORT-FUSELAGE 707 – One 707-100 variant incorporated a major structural change without a change in the hundred-series designation. This was the 707-138 developed for QANTAS, the Australian overseas airline. The fuselage of an otherwise standard 707-100 was shortened 10 ft aft of the wing. The object was to reduce structural weight so that the usual reduction of payload weight relative to the weight of fuel required for long flights could be minimized. This change altered the aerodynamic characteristics of the aeroplane and required extensive testing under US registration before certification under the 707-100 Type Certificate.

The 707-138 was not added to the 707-100 Type Certificate as such, but as the '707 Short Body'. The wording of the certificate was revised to identify the other 707-100s on it as 'Long Body' 707-100s.

This model also introduced a new feature, the engine ferry pod. This is a streamlined container resembling a C-97/B-50 auxiliary fuel tank, suspended from the port wing between the No. 2 engine and the fuselage.

Another five-engined jet, a QANTAS 707-138 seen ready for delivery with a spare engine carried in a streamlined container under the port wing. (*Boeing Photo 23226*)

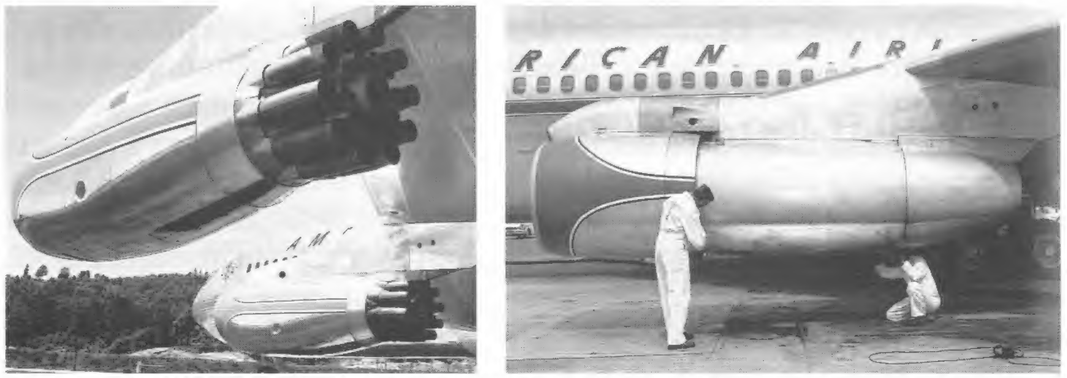


Photo at left shows nacelles, sound suppressors, and thrust reversers of American Airlines Model 707-123. Photo at right shown revised nacelle of 707-123B for more powerful JT-3D engine. (*Boeing Photos P-20798 and P-25438*)

This allows the carriage of a complete jet engine to points away from the airline's maintenance centre.

• 707-100B – An improved 707-100, the most notable changes being modification of the wing to use features introduced on the later Model 720, such as revised inboard leading edge and additional Krueger leading-edge flaps, a 3 ft increase in tailplane span, and installation of improved Pratt & Whitney JT3D-1 (or D-3) bypass or turbofan engines having 17,000 to 18,000 lb of thrust. The new engines produced a noticeable change in the appearance of the nacelles similar to that on the B-52G. Because of the discharge of high-velocity air well forward on the nacelle, airline colour schemes are seldom applied aft of the bypass discharge ports because the paint does not stand up under the heat and abrasion. On the B models, take-off run was greatly reduced, rate of climb and range increased, and the maximum speed increased to Mach 0.91. The first 707-123B, a conversion of a standard -123, flew on June 22, 1960, and received approval under the 707-100 Type Certificate on March 1, 1961.

This underside view of an American Airlines 707-123B shows the revised nacelle contours and the increased wing leading-edge sweep between the inboard engines and the fuselage that are distinguishing features of 707B models. (*Boeing Photo P-25324*)

TECHNICAL DATA - MODEL 707-100B

As 707-100 and previously described except:

Fuel:	17,334 US gal
Wing area:	2,521 sq ft
Empty weight	129,300 lb
Max speed:	627 mph
Cruising speed:	618 mph at 25,000 ft
Service ceiling:	42,000 ft
Climb:	5,050 ft/min

• 707-200 – The second 707 series, called Model 702-220 by Boeing but -200 by the FAA, was dimensionally similar to the -100 series except that larger Pratt & Whitney JT4A-3 engines of 15,800 lb thrust, similar to the military J-75, were installed for improved take-off performance at high-altitude South American airports at the request of the single customer, Braniff, which ordered five. Licensed under the 707-100 Type Certificate on November 5, 1959, Braniff's first 707-227 was delivered on December 3, 1959, and was in service by December 20.

707-200 series was similar to -100 except for installation of larger JT4 engines. This is 707-227 for Braniff. (*Boeing Photo P-23005*)

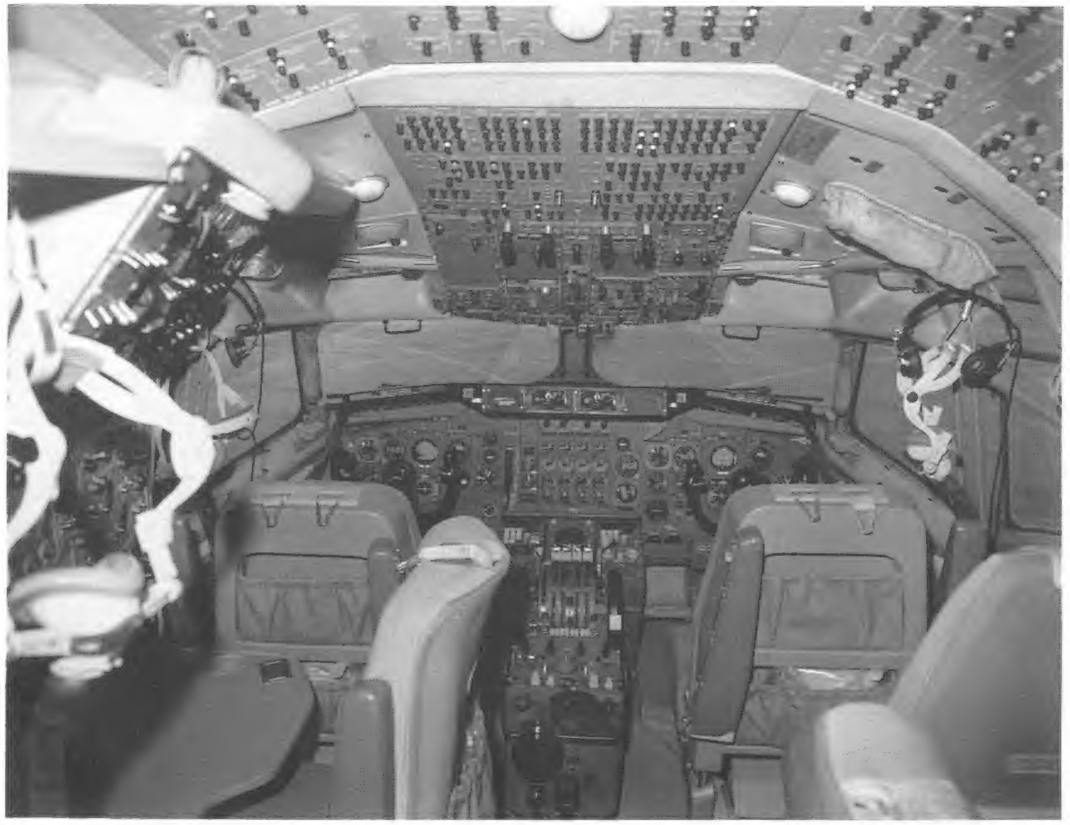
MODEL 707-300 INTERCONTINENTAL – Specifically designed for transocean flights and renamed to signify the fact, the -300 series (called -320 by Boeing) had a lengthened fuselage with accommodation for 131 first-class passengers or 189 tourist, the wing was lengthened and the trailing-edge contours near the fuselage were altered to further increase the area. The span of the horizontal tail was increased and power was increased by use of larger P & W JT4A-3 turbojets. The fuel capacity was increased to a normal 21,200 US gallons or to 23,500 with special tanks. Use of the underfin varied in the -300 series. All models delivered since 1960 have the higher tail and all earlier models have been fitted with it. The extensive differences between the -100/-200 models and the -300 made it necessary to license the -300 under a new Type Certificate; ATC 4A-26 was issued on July 15, 1959.

Pan American was the first customer, ordering 15 on December 24, 1955. These were given continuing registrations to PAA's six 707-121s. However, because some superstitious passengers might be hesitant about flying in an

Model 707-300 was enlarged Intercontinental model for overseas routes. SABENA 707-329 is shown with original small vertical tail. (*Boeing Photo P-23851*)

aeroplane with the number 13 on it, the N713PA registration was not used at the airline's request.

One 700-300, a -329 of the Belgian airline SABENA, made a remarkable record flight both for distance and capacity during the 1959 trouble in the Belgian Congo (now Zaïre). It made a 4,000-mile nonstop flight from Léopoldville to Brussels with 301 people aboard, including the crew.



Four-seat flight-deck of a long-range 707, with seats for navigator at left and flight engineer at right, behind the pilots' seats. (*Boeing Photo 4SK-04887*)

In October 1975 a Portuguese 707-30 topped that passenger figure with an evacuation flight from Angola carrying 342 passengers, plus crew and 19,000 lb of cargo. The distance was not specified.

TECHNICAL DATA - MODEL 707-300

Type:	Long-range transport
Accommodation:	Maximum 189 tourist passengers
Power plant:	Pratt & Whitney JT4A-3 15,800 lb thrust
Span:	142 ft 5 in
Length:	152 ft 11 in
Height:	41 ft 7 in
Wing area:	2,892 sq ft
Empty weight:	135,000 lb
Gross weight:	312,000 lb
Max speed:	623 mph
Cruising speed:	604 mph at 25,000 ft
Service ceiling:	37,200 ft
Climb:	2,890 ft/min
Range:	4,630 miles

• 707-300B – Improved -300 with a still longer wing, curved wing tips, additional and wider leading-edge flaps, and revised trailing-edge flaps that further alter the trailing-edge contour. Wing area was increased by more than the additional span by a method not readily detectable in photographs; the leading edge of the wing outboard of the outboard engines was extended five inches forward. Power plants are JT3D-3 turbofans fitted with double thrust reversers. Because of the extensive structural changes, these aeroplanes were all built as -300Bs and were not conversions. The -300B was licensed under the ATC of the basic 707-300 in January 1962.

Again, PAA was the first customer, ordering thirty-one 707-321Bs, on February 13, 1961, and putting them into service on June 1, 1962.

• **ADVANCED 707-300B** – Further improvements were made on the 707-300B, mainly to the wing, to create the 'Advanced 707-300B'. Additional leading-edge flaps were installed inboard of the engines and the trailing-edge flaps were revised. The additional area and revised flaps altered the lift distribution of the aeroplane over the basic Model 300 and largely nullified the problem of over-rotation on take-off, making it possible to discard the underfin.

TECHNICAL DATA - MODEL 707-300B

Type:	Long-range transport
Accommodation:	As 707-300
Power plant:	Pratt & Whitney JT3D-3 18,000 lb thrust
Span:	145 ft 9 in
Length:	152 ft 11 in
Height:	41 ft 7 in

An Aer Lingus Model 707-348C, a convertible model that can carry freight or passengers, or both simultaneously. (*Boeing Photo P-36008*)

Wing area:	3,010 sq ft
Empty weight:	140,000 lb
Gross weight:	335,000 lb
Max speed:	627 mph
Cruising speed:	607 mph at 25,000 ft
Service ceiling:	36,000 ft
Climb:	2,370 ft/min
Range:	6,160 miles

• 707-300C – The suffix letter C is used to indicate 'Convertible', a combined passenger/cargo version of the Advanced -300B fitted with a 7 by 11 ft cargo loading door at the left forward side of the cabin. The cabin floor was reinforced to accommodate the higher concentrated loads and a new and stronger undercarriage was used to accommodate the higher authorized landing weight. The interior of the cabin can be arranged to separate passengers and cargo to suit the user, such as passengers in the rear and cargo in the front, or the separation can be longitudinal. For convenience in loading when in the all-passenger configuration, the standard forward

World Airways' Model 707-373C is typical of 'Advanced 320C' models that do not use underfin. Note revised wing trailing edge shape. (*Boeing Photo P-32815*)

Chinese registrations on Boeing jetliners are confusing, since both the Republic of China, or Taiwan, and the Peoples Republic of China, on the Asiatic mainland, both use the national letter B and a number for their aircraft registrations. Notable differences are fuselage lettering and different national flags on the tail. B-1824 (*top*) is a 707-309C of China Airlines (Taiwan) and B-2410 is a 707-3J6C of CAAC based in the Beijing region of mainland China. (*Boeing Photo P-45669 and Photo by S R Lynn*)

passenger door is retained forward of the cargo door.

The cargo door contains passenger windows for use when in the passenger configuration, but these windows and others in the cabin are usually covered by temporary internal protective panelling when in the cargo configuration. Like the Advanced -300B, the -300C has the three-segment inboard leading-edge flaps and no underfin. The basic price of the 707-300 B and C models early in 1964 was approximately $6,750,000.

Again, Pan American was the first customer, ordering fifteen 707-321Cs on April 25, 1962. These were built in parallel with Pan American's 707-321Bs and continued the registration numbers of the first five -321Bs. Service began on June 3, 1963. The practice of separate dash numbers did not apply rigidly to the 707-300. Two PAA -321Cs were released to Continental, who operated them under that designation while six -321s of a TWA order were released to PAA and operated by them as -331s.

The -300 series also deviated from previous 707 practice in using dash numbers below -321, as shown in the appendix table that lists all 707-300 series aeroplanes in sequence of customer numerical assignment independent of B or C suffix letters. Advanced 707-300Bs are not identified by designation.

• 707-300F – Not an official Boeing 707 designation, but sometimes used as a convenient designation for 707-300Cs used for all-freight operations.

707-400 series is similar to -300 except for installation of Rolls-Royce engines instead of Pratt & Whitney. This is Model 707-436 for BOAC. (*Boeing Photo P-24664*)

MODEL 707-400 – The -400 was similar to the standard -300 except for the use of 17,500 lb thrust British Rolls-Royce Conway 50B bypass engines. These were the first fanjet engines installed in a 707 and are also an excellent example of 'offset' applied to the international aircraft purchase. Under this, the overall cost to the purchasing country is offset, or reduced, by the cost of equipment supplied by that country, in this case the Rolls-Royce engines. British Overseas Airways (BOAC) was the initial customer, ordering 16 for itself and two for its BOAC-Cunard subsidiary on April 24, 1956. The

D-ABOB (*top*) is a Lufthansa 707-430 with original small vertical tail and no underfin. D-ABOF is another 707-430 from the same order after addition of enlarged vertical tail and an underfin. (*Boeing Photos P-23771 and P-25728*)

Not all published photographs of airliners show accurate markings or registrations. Here Boeing retouched a photograph of BOAC 707-436 G-APFE for new customer Cunard Eagle Airways to use in publicity for its own 707s before their delivery. The original British registration was changed to an old discontinued one. (*Boeing Photo P-26736*)

Model 400 was approved under the 707-300 Type Certificate on February 12, 1960.

MODEL 707-700 – This single aeroplane was used by Boeing as a test-bed for the new CFM56 turbofan developed by CFM International SA, an international firm owned jointly by General Electric of the United States and SNECMA (Société Nationale d'Étude et de Construction de Moteurs d'Aviation) of France. This high-bypass-ratio engine was specially designed to have lower specific fuel consumption and lower noise levels. It first flew in 1977, delivering 20,000 lb of thrust, later raised to 23,000 lb. When installed as a replacement engine in an existing aeroplane such as the Boeing 707, it presents a very distinctive appearance because of its very short length and greater diameter.

Aside from testing the CFM56 engine, Boeing planned to offer new 707-700s with CFM engines to the market and to upgrade existing 707s through kits consisting of new engines and nacelles. This programme was

The Model 707-700 was the last civil 707 airframe built. It was used to test the General Electric/SNECMA CFM56 engines for possible use in further civil 707s or for retrofit to older 707s. (*Boeing Photo P-53902*)

not carried through in view of the fact that upgraded 707s would reduce the market for new Boeing Model 757s. The kit conversion idea was taken up by Douglas, however, which extended the service life of some DC-8s with new power packages. Although Boeing did not apply the CFM56 engine to further civil 707s, it did adopt that power plant for some military 707 variants, specifically KC-135s converted to KC-135Rs and to newly-built KE-3As, E-6As, and E-8As (*see* Chapter 14), plus the Model 737-300.

The 707-700 flew as such on November 27, 1979. After completing the CFM56 test programme, the aeroplane was converted to a 707-3W6C with P & W JT3D engines and delivered to the government of Morocco in April 1982. This was the last delivery of a commercially-configured Boeing 707.

C/n: 21956
Registration: N707QT (for Quiet); CN-ANR

The second Model 720 with original small vertical tail. This is Model 720-022 for United Air Lines.
(*Boeing Photo P-24089*)

MODEL 720 – Even before the long-range 707 entered service, Boeing began development of a derivative design for short- to medium-range routes and capable of operating from shorter runways. For a while, the new model had an identity problem. At first, it was called a 707-020, but this was changed to 717-020, possibly because its shorter fuselage was more like that of the Model 717/KC-135A. This was not satisfactory either, so the designation was changed again, to 720-020.

While little change was outwardly noticeable, the redesign was extensive and justified the use of a new model number. While using many 707 structural items and systems, the 720 is considerably lighter, 9 ft shorter than the standard 707-100, and uses a noticeably different wing. The sweep

of the leading edge between the inboard nacelles and the fuselage was increased to produce double taper and Krueger leading-edge flaps were installed for almost the full span. Power plants are the Pratt & Whitney JT3C-7 or C-12 of 12,000 lb thrust and fuel capacity was reduced to 11,835 US gal. Passenger accommodation is 110 first-class or 165 tourist.

The first 720 was built as a production aeroplane, many of its basic features that differed from the 707 having been tested on the Model 367-80. Like the 707s, early 720s had short vertical tails and no underfins. Later examples had a 36 in vertical fin extension and an added underfin, and early production aeroplanes were retrofitted. At first, the absence of a probe antenna on the fin provided an easy means of distinguishing a 720 from a 707, but this distinction was lost when some airlines specified the antenna. Since the 720 was built in only one size, the only variations in designation are the three-digit suffix numbers and letters identifying different airline customers and engine changes. ATC 4A-28 was issued on June 30, 1960.

The first customer was United Airlines, which ordered a total of twenty-nine 720-022s, with service beginning on July 5, 1960. American Airlines ordered ten 720-023s, but since it already had 707-123s in service, did not want to confuse the public with separate designations for two such similar-looking models; it called its 720s 707-Astrojets and actually painted that designation on the aeroplanes. All were later converted to 720-023Bs.

Model 720 production was relatively small, only 154 being built with the last one delivered on September 20, 1967. The 720 was replaced in its short-range use by the new and more efficient Boeing Model 727. At the end of March 1988, the high-time 720 had 69,333 flying hours and was also the high-landing 720 with 45,023 landings. Thirty-five 720s were still active world-wide at that time, but only ten remained in airline service by the end of 1988.

TECHNICAL DATA – MODEL 720

Type: Short to medium-range transport
Accommodation: 165 tourist passengers
Power plant: Pratt & Whitney JT3C-7 or -12, 12,000 lb thrust
Span: 130 ft 10 in
Length: 136 ft 2 in
Height: 37 ft 11 in
Wing area: 2,433 sq ft
Empty weight: 110,800 lb
Gross weight: 229,000 lb
Max speed: 627 mph
Cruising speed: 601 mph at 25,000 ft
Service ceiling: 38,500 ft
Climb: 2,100 ft/min
Range: 5,240 miles

A Model 720-047B for Western Airlines, with the turbofans that distinguish the B-model. The additional wing sweep angle between the inboard nacelles and the fuselage was an original feature of Model 720s. (*Boeing Photo P-27354*)

No, this psychedelic 720-023B was not chartered to a rock music group. It was delivered to American Airlines as N7551A in July 1961, then went to Pan American as N782PA. It was acquired by the Ecuadorian airline Ecuatoriana, registered HC-AZQ, and given the unusual livery shown. The colours of the markings include yellow, red, pink, grey, several shades of blue, and black. The Ecuador national colours of yellow, blue and red appear at the top of the fin and rudder. (*Boeing Photo K-26348-6*)

This worn-out and non-flying 720-027 was ready for scrapping when one side of it was painted to represent the Boeing Model 707-353B/VC-137C *Air Force One* as background for a television film. (*Photo by Peter M Bowers*)

MODEL 720B – Standard 720s converted to JT3D turbofan power or new aircraft using the fan engine as original equipment. The price was approximately equal to that of the Model 707-100 series. Empty weight increased to 115,500 lb, gross to 234,000 lb and a 707-300 nose undercarriage was adopted because of the higher gross weight. Cruising speed increased to 622 mph and rate of climb increased to 3,700 ft/min. Service ceiling was increased to 40,000 ft, and range to 4,150 miles.

Chapter 14

THE MILITARY 707

Two separate models evolved from the Model 367-80 prototype. In sequence of Boeing model numbers, the 707 airliner came first and then the USAF KC-135 series, which was designated by Boeing as Model 717 and 739. Actually, however, the Model 717, with later 739 variants, was ordered into production first. Because of its structural and functional differences from the 707, and its later model numbers, the 717/739 is presented in Chapter 15.

Although developed and marketed as a purely civil aeroplane, the 707 found many military buyers. Most were used in the transport role, often as specially-equipped executive versions for Heads of State. Some, however, were modified to perform or support tactical military operations.

Boeing offers a military conversion of the 707 to air forces seeking an aerial refuelling tanker. By converting a used 707, they can obtain an effective tanker at a fraction of the cost of a new airframe built for the purpose. Offered options are the KC-135-type flying boom on the aeroplane centreline, a hose-and-drogue assembly in that position, or new hose-and-

A USAF VC-137A in a representative situation when used as a VIP transport. Note the letters USAF on wing but the legend United States of America on the fuselage, a characteristic of diplomatic carriers. (*Boeing Photo P-28345*)

To demonstrate the feasibility of converting used Model 707 airliners to aerial tankers, Boeing fitted this 707-385C with Beech-built hose-and-drogue refuelling pods at the wingtips. (*Boeing Photo P-43826*)

drogue pods at the wingtips as developed by Beech Aircraft Company of Wichita, Kansas. Some tanker conversions have been sold, both on new airframes before delivery and on used airliners.

A very odd situation arose when numbers of 707-300 airliners retired by major United States airlines were purchased by the USAF. Some of these were stripped of their fanjet engines and certain structural parts, which were then used to upgrade part of the KC-135 fleet. Others, however, were given new Air Force model designations and serial numbers and put into military service some 18 years after they left the factory.

Military 707 variants with given official designations, either USAF or of other countries, are described in chronological sequence of alpha/numeric designation in the following paragraphs. Descriptions of undesignated variants then follow.

• YC-137 – Designation originally assigned to two KC-97Gs modified to test propeller-turbine power plants. Designations cancelled and replaced by YC-97J. Revived for use on USAF 707s.

• VC-137A – Three 707-153s were bought by the USAF 'off the shelf' as standard commercial aircraft instead of being built to a military specification as was customary. Only minor changes to the electrical system and a rearrangement of the interior were incorporated to create VIP transports. A special communications station was located forward, ahead of an eight-seat passenger compartment. The centre cabin was arranged as an airborne headquarters, with conference table, swivel chairs, film projection equipment, and divans convertible to beds. The aft compartment contained 14

The third of three Model 707-153s delivered to the USAF as VC-137As, photographed after an increase in the height of the vertical tail and the addition of an underfin. (*USAF Photo*)

reclining passenger seats. Three galleys and two dressing rooms were provided. There was passenger accommodation for up to 40, with flight crew and cabin attendants numbering 18. When the President is aboard an aeroplane, it is identified as Air Force One. The first VC-137A flew on April 7, 1959, and all were assigned to Andrews Air Force Base near Washington, DC, for the use of VIPs. All were redesignated VC-137B following installation of JT3D-3 turbofans.

C/ns:	17925/17927
USAF serial numbers:	58-6970/6972

• VC-137B – The three VC-137As were redesignated VC-138B after installation of P & W JT3D-3 turbofans, and the colour schemes were changed to the special powder-blue trim adopted for the first VC-137C. During the Carter Administration the VIP role of the VC-137B was seriously curtailed; the special colouring was removed and the aeroplanes were downgraded to plain C-137Bs.

• VC-137C – The first of two special 707-353Bs for the Office of the President of the United States was ordered in 1961. Special communications equipment and interior furnishings were essentially those of the VC-137A/B. The special colouring of the VC-137Cs was developed by the wife of the then-President Kennedy, even to the point of changing the shade

The first of two Model 707-353Bs delivered to the USAF as VC-137Cs had the underfin. Note the Presidential Seal on the nose and the more artistic fuselage lettering. (*USAF* Photo)

The second VC-137C was delivered without the underfin. (*Boeing Photo P-48720*)

of blue on the fuselage star insignia! The first VC-137C was delivered in October 1962. The second VC-137C, ordered ten years later, was delivered in August 1972 after initial flight-testing in civil markings. Both were still in presidential service in 1988, but will be replaced by Boeing 747s, designated C-25A.

C/ns:	18461, 20630
USAF serial numbers:	62-6000, 72-7000 (temporarily registered N8459)

• C-137C – Two additional plain C-137Cs were acquired in 1965 when the USAF took over two very late model 707-300s, the former Wardair 707-396C and a former TAP 707-382B that had been acquired by smugglers and then confiscated by the US government. The -396C was built in 1969 and the -382B in 1970.

C/ns	*USAF serial numbers*	*Former registrations*
20043	85-6973	C-FZYP
20297	85-6974	CS-TBF

Some military Boeing 707s were originally civil transports. This Canadian Armed Forces CC-137C was built for Western Airlines as a Model 707-347C. (*Boeing Photo P46441*)

The two EC-137Ds, prototypes of the E-3 series, were Model 707-320Bs modified. Note the plugged but still visible cabin windows. (*Boeing Photo R-0371*)

• CC-137C – Not a USAF designation, but the official Canadian Armed Forces designation for five 707-347Cs acquired from a cancelled Western Airlines order (N1506W/1510W). These are used in support of Air Force operations, two being fitted with Beech hose/drogue refuelling pods on the wingtips. All were delivered between February and May 1970.

C/ns:	20315/20319
Canadian armed forces serial numbers:	13701/13705 (13702 was N1785B for US testing)

• EC-137D – Two civil 707-320Bs were taken from the production line in 1963 and modified to serve as the prototypes for a new military Airborne Warning and Control System (AWACS). Structural modifications were minimal except to reinforce the fuselage to accept the Westinghouse AN/APY-1 radar system and large external radome. The airliner windows were filled in, but their outlines could still be seen to distinguish the EC-137Ds (later redesignated E-3A) from the production E-3As. Normal operating crew for the EC-137D/E-3A is 20. The two EC-137Ds were initially delivered in February and October 1972, and redelivered as E-3As in October 1978, for the first, and May 1977, for the second.

C/ns:	20518, 20519
USAF serial numbers:	71-1407, 1408

• LUFTWAFFE C-137s – Between September and November 1968 the Luftwaffe of the Federal German Republic obtained four new 707-307C transports through USAF channels. Because of this, these aeroplanes appear in some records as C-137s with USAF serial numbers.

C/ns	*USAF serial numbers*	*Luftwaffe serial numbers*
19997/20000	68-11071/11074	10-01/-04

• KC-137 – Designation assigned by Boeing to used 707-300C airliners converted to aerial tankers. Brazil acquired a fleet of four so designated, but note that the two Canadian tankers are still designated CC-137.

The four Model 707-307Cs for the Luftwaffe were built new and were procured by the USAF under the designation C-137. (*Boeing Photo P-43736*)

Brazilian Air Force serial numbers	*707 model*	*C/n*	*Original owner*
2401	-345C	19840	Seaboard World
2402	-345C	19842	Seaboard World
2403	-320C	20008	Boeing (to Varig)
2404	-324C	19870	Continental

Two other nations are known to operate or have on order 707 tanker conversions, Australia with four ex-Qantas 707-338Cs and Spain with two ex-TWA 707-331s, a B and a C, though not designated KC-137s.

• C-18A – The US Air Force purchased eight retired 300-323C airliners from American Airlines in January 1982. The lower numerical designation results from the fact that the original USAF C-series ended with the XC-142A of 1962 and started again for both the USAF and Navy at C-1. Models still in production under earlier designations retained the old designations on subsequent orders, as the VC-137C ordered in 1972 and the plain C-137Cs acquired in 1985. The C-18As, in spite of their structural similarity to the VC-137Cs, did not follow this procedure because they were not used in the same transport role.

The 1966–67 airliners were sent to Wright/Patterson AFB in Dayton, Ohio, where they were stripped of their airline furnishings, given the C-18A

Eight used Boeing 707-323C airliners were acquired by the USAF in 1982 and put into service as C-18As. (*Photograph by Dave Menard*)

Although Boeing 707-323Cs were built with passenger windows, some later converted to freighter configuration had the windows plugged, as on this USAF C-18A. (*Photo by Arnold Swanberg*)

designation, and put into service as crew trainers. Some retained their airliner windows but others, having been used as freighters, had them plugged. Three C-18As were later converted to EC-18Bs.

C/ns	*USAF serial numbers*	*Former civil registrations*
19336	81-897	N7563A
19380	81-898	N7565A
19381	81-895	N7566A
19382	81-892	N7567A
19834	81-893	N7569A
19518*	81-891	N7598A
19581*	81-896	N8401
19583*	81-894	N8403

*Converted to EC-18B

• EC-18B – Starting in 1985, the final three E-18As were converted to EC-18Bs A/RIA (Apollo/Range Instrumented Aeroplanes) with large telemetry reception nose radomes similar to those on the EC-135Ns.

• E-3A SENTRY – Production versions of the EC-137D AWACS prototypes with structural and equipment improvements and without airliner windows. In keeping with US joint services practices, the E-3 series was given the name Sentry. This was the first 'popular' name given to a Boeing military aeroplane since the B-52 and the KC-135. A total of thirty-four E-3As was procured for the USAF over an 11-year period, with deliveries beginning in March 1977. This included modification and redesignation of

The four EC-18B A/RIA aeroplanes were former C-18As fitted with EC-135N nose radar for electronic missions. (*Courtesy Dave Menard*)

A production E-3A in overall light grey and white USAF colouring. (*Boeing Photo*)

the two EC-137Ds. The last 10 were completed as improved E-3Bs and some earlier E-3As have been upgraded to E-3B.

A further 18 were acquired by the North Atlantic Treaty Organization (NATO) for surveillance and early warning operations in Europe, with deliveries from March 1981 to November 1984. Although assigned and carrying USAF serial numbers, the NATO E-3As are registered as civil aeroplanes in Luxembourg. Saudi Arabia also acquired five E-3As under USAF serial numbers but powered by CFM56 engines. These were flown to Saudi Arabia in USAF colours and markings and repainted there.

The Royal Air Force and the French Government also ordered E-3As with consecutive Boeing c/ns, seven for the RAF and four for France. French deliveries will be from May to September 1990 and the RAF deliveries will be in 1991.

The eighteen E-3A aeroplanes for the North Atlantic Treaty Organization (NATO) carry Luxembourg civil markings rather than military serials. The letters OTAN abbreviate the French words Organisation du Traité de l'Atlantique Nord. (*Boeing Photo R-2153*)

USAF E-3A c/ns	*USAF serial numbers*
21046, 21047	73-1674, 75-556
21185	73-1675
21207/21209 (3)	75-557/559
21250	75-560
21434/21437 (4)	76-1604/1607
21551/21556 (6)	77-351/356
21752/21754 (3)	78-576/578
21755/21757 (3)	79-1/3
22829/22831 (3)	80-137/139
22832, 22833 (2)	81-4,5
22834, 22835 (2)	82-6,7
22836, 22837 (2)	83-8,9

NATO E-3A c/ns	*USAF serial numbers*
22855, 22838/22855 (18)	79-442/459

Saudi Arabian E-3As	
22833/22837 (5)	82-66/70

RAF E-3As	*RAF serial numbers*
24109/24114, 24999 (7)	ZH100/106

French Air Force E-3As	*French serial numbers*
24115/24117, 24510 (4)	SDA 201/204

• KE-3A – Eight tanker versions of the 707-300 were ordered by the Royal Saudi Air Force through USAF channels to support their five E-3As and other aircraft. These have the Boeing flying boom on the centreline and Beech pods at the wingtips. In spite of their E-3A designation, they do not have the E-3A radome. The KE-3 designation was chosen in preference to a seemingly more logical KC-135 designation because the KE-3As have 707-300 airframes that differ greatly from the KC-135 but are virtually identical to those of the E-3A. Further, the KE-3As have the CFM56 engines, not used in either KC-135As or USAF E-3As.

A Royal Saudi Air Force KE-3A, still in USAF markings, preparing to refuel another KE-3A during a test flight in the United States. (*Boeing Photo FA159879*)

The prototype US Navy E-6A. Production aircraft have the same all-white colouring. Note wingtip electronic installations and that only the last five digits of the Navy Serial Number 162782 are used. (*Boeing Photo*)

C/ns: 23422/23429
USAF serial numbers: 82-71/76, 83-510,511

• E-3B – The last ten USAF E-3As were completed as E-3Bs with standardized NATO AN/APY-2 radar and additional and improved electronic equipment. Some earlier E-3As have been upgraded to E-3B standard and redesignated.

E-3B c/ns (as built): 21757, 22829/22837
USAF serial numbers: 79-3, 80-137/139, 81-4,5, 82-6,7, 83-8,9

• E-6A HERMES – After the US Navy operated some borrowed USAF NC-135As and NKC-135As in the 1970s and 1980s, it decided that the basic 707-300C airframe would be suitable for its long-range communications relay missions, called TACAMO, meaning 'Take Charge and Move Out'. A single prototype, a Boeing 707-300 airframe fitted with CFM56 engines, was ordered, and was soon followed by an order for six production examples of a planned fifteen. Later, the order was increased to sixteen to replace a production E-6A to be transferred to the US Air Force as the third J-Stars prototype.

The white-painted prototype was rolled out of the Boeing Renton plant on December 18, 1986, and first flew on June 1, 1987. It, and the first production E-6A, were still under Boeing ownership when turned over to the Navy for further development and testing in May and June 1988 respectively. Deliveries of fully-equipped E-6As are scheduled as five in 1989, nine in 1990, and two in 1991.

Known c/ns	*Known US Navy serial number*
23420, 23889, 23890	162782/162784
23891/23893	162918/162920
23894, 24500, 24501	164386/164388

• E-8A – As prototypes for a joint US Army/US Air Force programme for battlefield management in Europe in the early to mid-1990s, identified as

The first of two camouflaged ex-airline 707-300Cs used as prototype aeroplanes for the Grumman J-Stars programme. Note the distinctive J-Stars radome beneath the nose. (*Boeing Photo*)

the Joint Surveillance Target Attack Radar System (J-Stars), the USAF acquired two retired Boeing 707-300C airliners (see J-Stars Prototypes, following). Production of twenty-one J-Stars aeroplanes is expected.

• E-8B – Air Force experience with refurbishing retired 707 airliners for the C-18B programme revealed that it would be more cost-effective to acquire new airframes than to refurbish old ones, so the production J-Stars aeroplanes will be structural duplicates of the US Navy E-6A in J-Stars configuration. As a result of this decision, a third J-Stars prototype will be a production E-6A airframe transferred to USAF as E-8B; the production aeroplanes will also be E-8Bs.

• J-STARS PROTOTYPES – In 1985 the Air Force acquired two additional ex-airline 707-300s (Qantas 707-338C, American Airlines 707-323C) to serve as actual prototypes for the J-Stars system. These were refurbished by Boeing Military Airplanes in Wichita and were ferried in full military camouflage and markings, but with civil registration, to a Boeing facility established at Melbourne, Florida, to support them during use by Grumman, the prime USAF contractor for the J-Stars programme. The first flight under Grumman jurisdiction was made in April 1988.

The USAF serial numbers for the two aeroplanes are misleading as they appear on released serial number lists. They are not assigned to the Boeing aeroplanes as such, but to the Grumman project that uses them. In spite of their USAF ownership these aeroplanes did not originally carry USAF designations. They were unofficially referred to as C-18s because they were maintained with C-18 publications and support equipment while developing the J-Stars/E-8 electronic installations. Designations later became E-8A. A third prototype is to be a Navy E-6A redesignated E-8B.

USAF serials	*C/ns*	*Former registrations*	*Current registrations*
86-416, 417	19626, 19574	VH-EAF, N8411	N77OJS, 78OJS

The Peace Station aeroplanes were built for the IIAF as Boeing Model 3JCs fitted with KC-135A flying booms and Beech hose-and-drogue wingtip pods. (*Boeing Photo P-51521*)

• PEACE STATION – Between 1974 and 1978 the Imperial Iranian Air Force (IIAF, later Iranian Islamic Air Force) bought four used Boeing 707-125 airliners and fourteen new 707-3JCs. The four 707-125s were originally delivered to Eastern Air Lines, who immediately sold them to TWA, who resold them to Iran. The fourth was sold back to TWA before conversion to a military transport.

The fourteen new 707-3JCs were code-named 'Peace Station' by Boeing and the US Air Force that initially supported their operation. The first six were delivered with the KC-135A aerial refuelling boom, three with cabins in passenger configuration and three as cargo aircraft. The next six were delivered with Beech hose/drogue pods on the wingtips in addition to the boom; the first six had the Beech pods added later. The last one was delivered as a special VIP transport with civil registration replacing the IIAF serial number. The Iranian markings were applied at Boeing, but just before delivery the IIAF requested a change of number, which was accomplished after some of the aeroplanes had been photographed.

707-125 c/ns	*Original civil registrations*	*IIAF serial numbers*
20080, 20081	N93113, 93114	5-282, 284; to 5-8103, 8104
20082	N93118	5-286; to 5-8107
707-3JC c/ns	*Original IIAF serials*	*New IIAF serials*
28030/2835 (6)	5-241/246	5-8301/8306
21123/21125 (3)	5-207/209	5-8307/8309
21426/21129 (4)	5-8310/8313	—
21475	5-8314	EP-NHA

• NATO TRAINERS – Starting in mid-1986, three former Sabena 707-329Cs were transferred to NATO for modification as flight crew trainers for the NATO Airborne Early Warning Force. The work was a truly international effort, involving Dornier in Germany, Sabena, THY in Turkey, Air Portugal, Aeronavali in Italy, and Boeing Military Airplanes in the USA.

Flight decks were modified and re-equipped to conform to the NATO E-3As, with auxiliary power unit and a simulated in-flight refuelling system added. As with the E-3As, Luxembourg civil registrations are used, with the aeroplane c/n tied in to the letters LX-N as follows:

Former registration	*C/n*	*Luxembourg registration*
00-SJL	19996	LX-N19996
00-SJM	20198	LX-N20198
00-SJN	20199	LX-N20199

• USAF TRAINERS – Boeing supports the USAF E-3A fleet with a flight-crew training programme based at Tinker AFB, Oklahoma. In addition to classroom flight-deck simulators, two former TWA 707-331Cs have been converted to E-3A flight-crew trainers that operate under civil registration but carry USAF colouring and markings. The flight-decks have been modified to E-3A standard and a non-functional in-flight refuelling receptacle has been installed. The radome and associated electronic equipment is not installed.

Former registrations	*C/ns*	*Current registrations*
N788TW	18713	N131EA
N15710	19566	N132EA

Up to September 30, 1988, orders for Military Model 707s were 120, consisting of 68 E-3s, 6 E-6As, 8 KE-3As, 3 -120s, 4 -320Bs and 31 -320Cs. All had been delivered except 12 E-3As and the 6 E-6As.

Chapter 15

THE C/KC-135 TANKER/TRANSPORT

The first order for Boeing jet transports was placed by the USAF for tanker-transport versions. These were initially identified by Boeing as Model 717 and were publicised as the Stratotanker. In general references, the USAF often combined the transport and tanker roles in the designation C/KC-135. While generally similar to the commercial 707-120 model except for military features, including a crew escape chute in the pilots' compartment, it should be emphasized that the C/KC-135 was designed to an entirely different service-life philosophy. Considering that the military model would fly only one-tenth as much as a corresponding commercial model in a year, the C/KC-135 was designed to a safe-life requirement while the commercial model was designed to be fail-safe. These differences, which also called for different materials (7178 aluminium alloy in the KC-135A and 2024 alloy in the 707), justified the different Boeing model numbers.

Peak production reached 15 units a month, but this was cut back to nine a month. Some early KC-135As were diverted to special missions, including service as flying command posts for the Strategic Air Command (SAC). As the versatility of the C/KC-135 series became apparent, many were diverted to other special missions that resulted in the greatest number of series suffix letters ever assigned to a single USAF aeroplane model.

A continuing series of structural upgrading modifications, plus the installation of later or more efficient power plants and instrumentation, ensure

A Boeing KC-135A refuelling a Boeing B-52G. (*Boeing Photo P-21938*)

An early KC-135A with original small vertical tail. The reinforcing bands for the rear fuselage are evident in this photograph. (*Boeing Photo P-25836*)

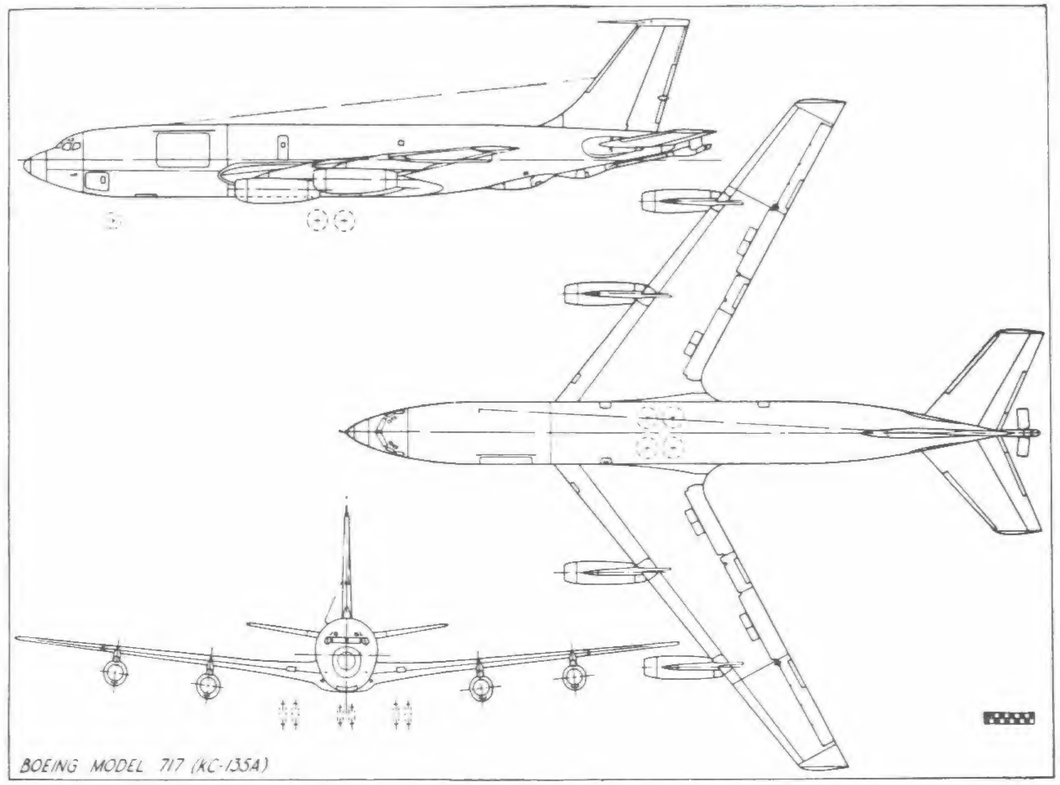
the continued use of the C/KC-135A tanker fleet well into the 21st Century.

C/KC-135 PRODUCTION VERSIONS

Altogether, 820 C/KC-135 aircraft were built in the Boeing Renton plant, 732 as KC-135As. Deliveries were made under six USAF designations as described here, plus one foreign variant.

• KC-135A STRATOTANKER – The Boeing model designation given to the first twenty-nine KC-135As was 717-100A. Later procurements, still as KC-135As, were the 717-146 and -148. The KC-135A was similar in dimensions to the 367-80 prototype although only one cargo door was provided on the upper deck. The only cabin windows were in the two escape hatches on each side of the fuselage. All body tanks for the boom refuelling system, which combined with the normal wing tanks for a total capacity of 31,200 US gallons, were carried in the unpressurized lower compartments, leaving the upper deck entirely clear for bulk cargo and up to 80 passengers in removable seats. Initial refuelling technique was by means of the boom nozzle only, but an adapter was soon provided to permit probe-and-drogue refuelling from the boom. Originally, the vertical tail was the same as that of the 707-120, but was changed at the 583rd unit, 62-3532, to the tall design and the powered control of the later 707s. Previously-delivered models were modified by kits. The first flight of a KC-135A was on August 31, 1956, and deliveries to operating units began on June 28, 1957. Final delivery was in January 1965. Initial cost of a KC-135A, according to USAF figures, was approximately $3,670,000. Because of extensive modernization programmes and airframe upgrading, the KC-135A is now carried in the USAF inventory at a considerably higher figure.

Soon after delivery of the early KC-135As it became apparent that the impingement of turbojet sound waves was causing sonic fatigue in the 7178 aluminium skin of the rear fuselage. This was overcome by bonding 25 circumferential stiffeners in the form of thin aluminium strips to the fuselage in the area between the rear end of the wing root fillet and the front



of the dorsal fin. These are very evident in some photographs.

To provide other government agencies with high-performance airline-type jet aeroplanes for evaluation before the availability of commercial models, two KC-135As were lent to the FAA.

TECHNICAL DATA - KC-135A

Type:	Military tanker-transport
Accommodation:	Up to 80 passengers
Power plant:	Pratt & Whitney J57P-59W, 13, 750 lb thrust
Span:	130 ft 10 in
Length:	136 ft 3 in
Height:	38 ft 4 in
Wing area:	2,433 sq ft
Empty weight:	98,466 lb
Gross weight:	297,000 lb
Max speed:	600 mph
Cruising speed:	552 mph at 30–45,000 ft
Service ceiling:	50,000 ft
Climb:	1,290 ft/min
Range:	3,000 miles

Boeing Model	*C/ns*	*USAF serial numbers*
717-100A	17234/17262	55-3118/3146
717-146	17340/17407	56-3591/3658
717-148	17489/17585	57-1418/1514

717-148	17725/17745	57-2589/2609
717-148	17746/17875	58-1/130
717-148	17931/18011	59-1443/1523*
717-146	18088/18143	60-313/368
717-146	18168/18232	61-261/325
717-146	18480/18563	62-3497/3580
717-146	18593/18662	63-7976/8045
717-146	18719/18736	63-8871/8888
717-146	18768/18780	64-14828/14840

*59-1481 and 1518 to FAA as N96 and N98

• C-135A STRATOLIFTER – Forty-five cargo/passenger versions of the 717 were ordered without the tanker feature as Boeing Model 717-157. Capacity was increased to 126 troops. The floor was reinforced and additional toilet facilities were installed. Initially, the only noticeable outward change was the use of the higher post-1959 707 vertical tail. Although not included in the 45 aircraft C-135A order, three standard KC-135As were modified to partial C-135A standard and delivered as C-135As in June and July of 1961. These three aircraft (60-356, 357, 362) were referred to as C-135A 'Falsies' because they were not true C-135As and could be distinguished by their original short KC-135A vertical tails and external vestiges of the boom system. Provisions for reconverting to the tanker configuration were retained. The last thirty C-135As were delivered as C-135Bs.

C/ns	*USAF serial numbers*
18144/18153 (10)	60-369/378
18233/18237 (5)	61-326/330

• RC-135A – Four were delivered as Boeing Model 739-700, using the J-57 engines of the KC-135A. The refuelling system was omitted and a fuel dump tube replaced the flying boom. Changes in the forward fuselage deleted one forward fuel tank. A camera bay was installed aft of the nose

A small-tail Boeing C-135A 'Falsie', completed as a transport but retaining the in-flight refuelling system less boom. (*Boeing Photo P-27231*)

The C-135B is a cargo/transport version of the KC-135A with turbofans but without refuelling provisions. (*Boeing Photo P-29398*)

undercarriage. This contained a sliding panel that exposed a large, flat, optically-ground glass plate for the cameras. Deliveries were in 1965–66 at unit costs of $10,331,000, due largely to the special equipment installed.

C/ns:	18670/18673 USAF
USAF serial numbers:	63-8058/8061

• C-135B – The last thirty C-135As were completed as C-135Bs with P & W TF33-P-5 turbofans. The increased power required an increase in the span of the horizontal tail, accomplished by extending the tailplane outward

Pilots' stations of the C-135B. Note the fuel management panel ahead of the power levers, and weather radar to the right of the pedestal. (*Boeing Photo P-28569*)

beyond the elevators. These changes resulted in a new Boeing model number, 717-158. Five C-135Bs were converted to VC-135Bs, and ten were converted to WC-135Bs.

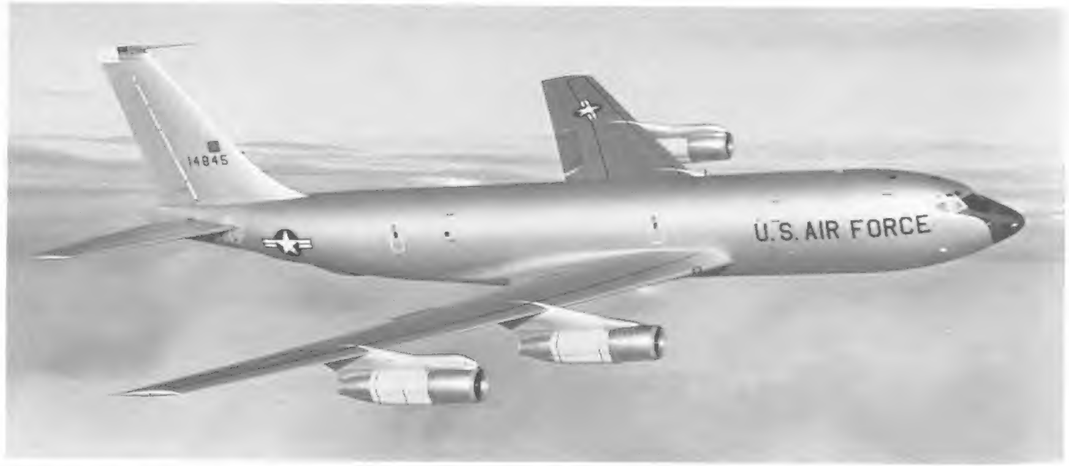
C/ns	*USAF serial numbers*
18238, 18239 (2)	61-331/332
18292, 18333, 18340/18350 (13)	61-2662/2674
18465/18479 (15)	62-4125/4139

• KC-135B – Seventeen aircraft completed with turbofans as KC-135B (Boeing Model 717-166). While carrying the flying boom, they are intended for use as SAC Airborne Command Posts and are provided with air refuelling receptacles (ARR Systems) so that their normal 8½ hr cruising range can be extended. Additional electrical capacity is provided and the cargo deck is divided into compartments for office, communications, and living areas. At least one of these is in the air at all times with a general officer aboard so that command capability will not be lost in case of surprise nuclear attack. Another is on standby. Most KC-135Bs were redesignated EC-135C in October 1964.

C/ns	*USAF serial numbers*
18564/18568 (5)	62-3581/3585
18663/18699 (7)	63-8046/8052
18701/18705 (5)	63-8053/8057

• RC-135B – Ten electronic reconnaissance versions similar to the RC-135A except fitted with turbofans and other structural features of the C-135B. Interior work was done by Martin on bare airframes supplied by Boeing as Model 739-445B. Deliveries from Boeing were in 1964 and 1965, and the aircraft became RC-135Cs following modification.

C/ns	*USAF serial numbers*
18076	63-9792
18781/18789	64-14841/14849



The RC-135B is similar to C-135B except equipped for photographic and electronic reconnaissance missions. Silver-grey paint was applied at the factory instead of leaving the natural metal finish. (*Boeing Photo P-37135*)

A C-135F of the French Air Force refuels a Dassault Mirage IV through the probe adapter on the end of the flying boom. (*Courtesy Alain Pelletier*)

• C-135F – Twelve tankers ordered for the French Air Force. The K-for-tanker prefix is not used in Boeing records, special identification being provided by the suffix F-for-France. These aircraft were delivered in 1964 with French Air Force insignia but with standard USAF serial numbers. Boeing Model 717-164. In the early 1980s eleven of these were re-engined with GE/SMECA engines as C-135FRs.

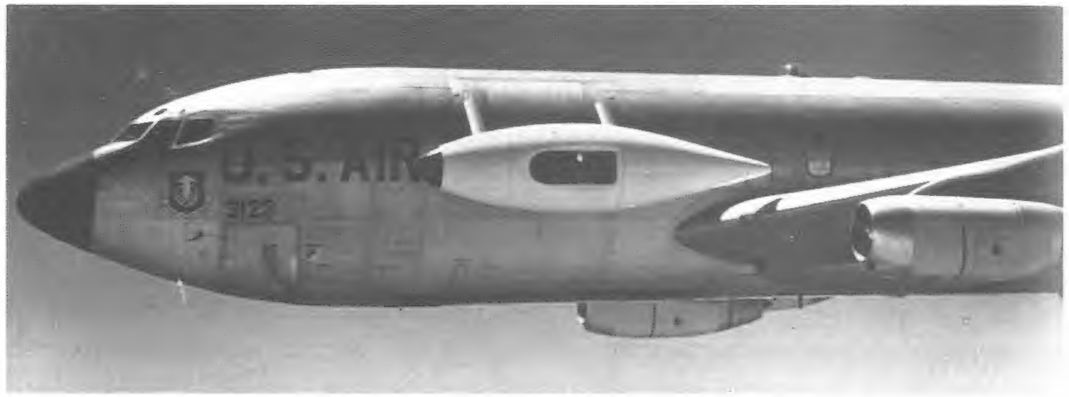
C/ns	*USAF serial numbers*
18679/18684	63-8470/8475
18695/18700	63-12735/12740

C/KC-135 CONVERSIONS

Although designed as a tanker-transport, the basic Model 717/739 was soon and easily adapted to other specialized military missions. Some aircraft acquired several different series designations as they were transferred from one user organization to another and re-modified for different use. Two NKC-135s were loaned to the US Navy and two NC-135As were turned over to the National Air and Space Administration (NASA). In addition to accumulating an unprecedented number of suffix series letters and some special-purpose designation prefixes, some C/KC-135As retained their existing suffix letters but acquired the J-prefix that indicated special test status. Others were so extensively modified for testing that they were given the N-prefix, meaning that it was uneconomical to ever reconvert them to standard configuration.

Some of the test requirements undertaken by the C/KC-135 were unforeseen when the aeroplane was designed. One interesting example: the spacious cabin and high performance of the aircraft enabled it to fly the 'Ballistic Curve' manoeuvre that allowed the astronaut trainees to experience relatively extensive periods of weightlessness.

The many C/KC-135 redesignations known up to May 1988 are identified here in alphabetical order of suffix letter, with grouping by special-purpose prefix also in alphabetical order. USAF serial number



Four examples of the numerous external detail differences between various KC-135A conversions carrying the NKC-135A test designation. (*Photos by Boeing, E M Sommerich and Gordon S Williams*)

Test aeroplanes with the J-prefix can be restored to original configuration relatively easily. This JKC-135A, still with flying boom attached, carries satellite tracking equipment. (*Photo by Peter M Bowers*)

assignments to some of the modified C/KC-135s used for classified missions are not available and individual serials for the many KC-135As converted to KC-135Es and KC-135Rs are too numerous to list here.

• EC-135A – In 1965, eleven KC-135As were converted to EC-135A with additional avionics to serve as radio relay link aircraft in support of SAC's Post-Attack Command Control System. They retained their air refuelling capability. The first five were subsequently converted to EC-135Ps.

USAF serial numbers: 58-7, 11, 18, 19, 22
61-262, 278, 287, 289, 293, 297

• JKC-135A – At least five early KC-135As were modified for test work and given the J-prefix to identify their status.

Known USAF serial numbers: 55-3121, 3124, 3127, 3134
56-3596

• NC-135A – Three former MAC C-135As were converted to NC-135As in 1964 for the Atomic Energy Commission (AEC). They were later reassigned to NASA. By 1969, they were turned over to the Air Force Systems Command (AFSC).

USAF serial numbers: 60-369/371

An all-grey NC-135A on loan to the US Navy. (*Photo by Norman E Taylor*)

An all-grey RC-135A in the markings of the Military Airlift Command, a joint Services organization that absorbed the former MATS. (*Boeing Photo P-39957*)

• NKC-135A – By 1969, a total of fourteen KC-135As had been so drastically modified that they were redesignated as NKC-135A, denoting their permanent test status. These aircraft were assigned to AFSC.

Two NKC-135s were loaned to the US Naval Electronic Systems Command for electronic warfare research by the Fleet Electronic Warfare Group. This resulted in the Navy's later order for Boeing E-6A aircraft.

Known USAF serial numbers: 55-349, 3122, 3123, 3125, 3128, 3129, 3132

• RC-135A – Four C-135As were modified as RC-135As for the Military Air Transport Service (MATS). This organization was later replaced by a new Joint-Services organization, the Military Airlift Command (MAC).

• VC-135B – Five C-135Bs were completed as specially-equipped transports for high-ranking personnel, the fittings justifying the V-prefix. Under the Carter Administration, the aircraft were downgraded to plain C-135B status and lost their distinctive blue-and-white colour scheme based on that designed by Jacqueline Kennedy for the first VC-137C.

USAF serial numbers: 62-4125/4127, 4129, 4130

• C-135B(TRIA) – Three C-135Bs modified by the Douglas Aircraft Company of Tulsa, Oklahoma, for special electronic work. The main feature was a 10 ft nose extension similar to that of the later C-135N (which see) and a distinctive theodolite pattern painted on the starboard side of the nose.

• WC-135B – In 1965, ten MAC C-135Bs were converted into WC-135Bs for the weather reconnaissance role and operation by the Air Weather Service. The fuel-dump system was retained and an ARR system was installed. These aircraft may be distinguished by the U-1 foils mounted on the over-wing escape hatches, which gather ambient air to trap air particles for sampling.

A former VC-135B that was redesignated C-135B(TRIA) when fitted with a 'Duckbill Platypus' nose and prominent theodolite markings. (*USAF Photo*)

One aeroplane was loaned to TAC for use as a lead-in trainer for the E-3 Sentry programme at Tinker AFB, Oklahoma. The aircraft was subsequently returned to its weather mission when Boeing won a contract to employ two ex-airline 707s for the training role. The lead-in programme saved wear and tear on the E-3s.

Two of the WC-135Bs were converted to C-135Cs for use by MAC and one other became a C-135C for use by AFSC.

USAF serial numbers: 61-2665/2674

• C-135C – Three C-135As were refitted with TF33-PW102 engines and redesignated C-135C to continue the same mission.

• EC-135C – Fourteen KC-135B flying command posts redesignated. Normal complement is five crew members, one general officer, and his 10-man staff. While equipped with a refuelling receptacle in the nose, the RC-135C can also draw fuel from bomber aircraft by reverse action of its flying boom. Three became EC-135Js.

USAF serial numbers: 62-3581/3585
62-8046/8054

The WC-135Bs replaced WB-50s for weather reconnaissance missions. (*Courtesy Victor D Seely*)

The EC-135C being refuelled from a KC-135A was originally designated KC-135B. Note additional antennae on wingtips and retention of flying boom. (*Boeing Photo P-36027*)

• RC-135C – Immediately upon delivery, the ten RC-135Bs were sent to the Martin Aircraft Company in Baltimore, Maryland, where they were converted into RC-135Cs for use by SAC. The refuelling boom was replaced by a fuel-dump tube and the boom operator's station was converted into a camera bay. Large cheek sensors were installed along the forward fuselage and HF antennae were added to the wingtips. All were subsequently converted to RC-135U and RC-135V.

• KC-135D – The four MAC RC-135As were turned over to SAC in 1972 for use as command support aircraft but were soon converted to KC-135D tankers. The reason for the new designation was that the aeroplanes were originally built to a MATS configuration which employed a flight engineer. Rather than increase the cost of retrofit, SAC opted to retain the flight engineer's station and redesignate the aeroplanes instead of converting them fully to KC-135A configuration. KC-135Ds have since been upgraded by the retrofit of TF33-PW102 turbofans without change of designation.

• RC-135D – During 1962 and 1963, four KC-135As were converted to RC-135Ds. The refuelling boom was replaced by a fuel-dump tube, an ARR system was installed, and an integral static boom/pitot system was installed at each wingtip. These aircraft were readily identifiable by their 'thimble' noses and tubular antennae extending forward from the wing roots. One crashed and the remaining three reverted to KC-135As between 1975 and 1979.

USAF serial numbers: 59-1491, 60-356, 357, 362

• C-135E – Two C-135As in the SAC inventory and one from TAC were retrofitted with TF33-PW102 engines and became C-135Es for use in combat support roles.

• EC-135E – Several KC-135As were refitted with TF33-PW102 engines and redesignated EC-135E to continue the same mission.

• KC-135E – Beginning in 1982, KC-135As used by the Air National

KC-135As assigned to the Air National Guard are being refitted with Pratt & Whitney JT3D engines removed from retired Boeing 707 airliners and redesignated KC-135E. (*Photo by Norman E Taylor*)

Guard (ANG) and USAF Reserve (AFRES) were retrofitted with JT3D engines removed from retired airline Boeing 707s. Basically, this engine is the same as the USAF Pratt & Whitney TF33-P5s, with the addition of a single compressor stage. The commercial JT3D has the USAF designation TF33-PW102. This retrofit offered significant state-of-the-art improvements over the earlier 1950s vintage, water-injected J57s. These engines retained the commercial thrust reversers, thus enhancing wet runway operations. KC-135As retrofitted with these engines are redesignated KC-135E and should not be confused with the RC-135E, which has other engines. Approximately 140 KC-135As had been converted to KC-135Es by April 1988, in a continuing programme.

• NKC-135E – One AFSC NKC-135A was retrofitted with TF33-PW102 engines and redesignated NKC-135E to continue the same mission.

• RC-135E – A single MATS C-135B, 62-4137, was converted to RC-135E. A thimble nose radar antenna and an integral static boom/pitot system were installed. A pair of small pods were added inboard of the inboard engines; one housing an auxiliary power unit and the other an air conditioning unit. A large fibreglass fairing was installed on the starboard forward fuselage. The flying boom was replaced by a fuel-dump system and an ARR system was installed.

• EC-135G – Four KC-135As were converted to EC-135Gs in 1965. The boom refuelling system was retained, an ARR system was installed, and HF probe antennae were installed on each wingtip. These serve as airborne launch control centres and radio relay link aircraft for SAC.

USAF serial numbers: 62-3570, 3579, 63-7994, 8001

• EC-135H – In 1968, five KC-135As were converted to EC-135Hs as airborne command posts. The boom refuelling system was retained and an ARR system was added. Two HF probe antennae are located on the wingtips, and a trailing wire antenna system is installed. TF33-PW102 turbofans have been retrofitted. The EC-135Hs are operated by United

The first KC-135A has been modified as an Aerial Command Post and redesignated EC-135K. It is still in service more than 32 years after its first flight. (*Boeing Photo P-39531*)

States Air Forces Europe (USAFE) and Tactical Air Command (TAC).

Known USAF serial numbers: 61-282, 285, 291

• EC-135J – Three KC-135Bs equipped as flying command posts.

• EC-135K – Several KC-135As were converted to EC-135K airborne command posts for TAC. A fuel-pump tube replaced the refuelling boom, HF probe antennae were mounted at each wingtip, and TF33-PW102 turbofans have been retrofitted. No more than two of these aircraft have been in service at any one time; the additional aircraft were replacements for others lost in service.

It is interesting to note that the original KC-135A, 55-3118, was converted to an EC-135K after serving as a test aircraft, and still served in 1988. This is probably a record for any military aircraft model, the prototype serving as a first-line mission aircraft 32 years after its first flight.

• EC-135L – In 1965, eight KC-135As were converted to EC-135Ls to serve as part of the SAC Post-Attack Command and Control System (PACCS). The refuelling boom was retained and an ARR system installed. The EC-135Ls have red and white radiation hazard markings applied near the refuelling pod.

Known USAF serial numbers: 61-279, 281, 283

• RC-135M – During 1967 and 1968, six C-135Bs were converted to RC-135Ms. Both the thimble radar nose and integral static boom/pitot system were installed. The fuel-dump system was retained and the refuelling pod was replaced by a double-lobed antenna fairing. A flat-sided, tear-drop-shaped antenna was added to each side of the aft fuselage ahead of the tailplane. All were sbsequently converted to RC-135Ws.

• C-135N – Four MAC C-135As were converted by Douglas-Tulsa to C-135Ns. Their most noticeable feature, derived from the C-135B-TRIA, is the 10 ft long 'Duckbill Platypus' nose extension. This houses a 7 ft (2.13

The 'Platypus' noses installed on EC-135Ns by Douglas identified aeroplanes used in the ARIA and A/RIA programmes. (*Photo by Norman E Taylor*)

metre) diameter parabolic dish antenna, the largest of its kind ever installed in an aeroplane. The C-135Ns also carry the starboard-side theodolite pattern seen on the C-135B(TRIA) aircraft.

These aeroplanes were used initially as Apollo Range Instrumented Aircraft (ARIA) in the US space programme. When that programme ended, the aeroplane mission was redesignated as Advanced Instrumented Range Aircraft (A/RIA).

• EC-135N – Four EC-135Ns, also converted at Douglas-Tulsa, were similar to the C-135N. They did not have the theodolite pattern but did have provision for an Airborne-Lightweight Optical Tracking System (A-LOTS) pod to be suspended from the cargo door. The A-LOTS pod contains a telescope with a 200 mm lens and provisions for a 70 mm high-speed motion picture camera and two television cameras. A sighting blister for the A-LOTS equipment is located on top of the fuselage. Because of increasing demands on the system, similar equipment has been retrofitted to former American Airlines Boeing 707-323Cs designated EC-18Bs.

• EC-135P – The five KC-135As that became the first EC-135As were converted to EC-135Ps to serve in an airborne command post system for both TAC and PACAF. The refuelling booms have a reverse refuelling capability, HF probe antennae are installed at the wingtips, and TF33-

EC-135Ps are former EC-135As retrofitted with Pratt & Whitney TF33 turbofans for use as Aerial Command Posts while retaining their flying booms. (*Boeing Photo P-41783*)

PW102 turbofans have been retrofitted. The EC-135Ps have red and white radiation hazard markings applied near the refuelling pod.

• KC-135Q – A total of fifty-six KC-135As were modified as KC-135Qs specifically to support the Lockheed SR-71 Blackbirds. Externally these can be identified by the addition of a single TACAN antenna used to rendezvous with the SR-71. Internally, the aircraft have a modified fuel system which will accept the JP-7 fuel used by the SR-71. The 9th SRW at Beale AFB, California, has two tanker squadrons equipped solely with the KC-135Qs and other KC-135Qs are dispersed throughout the SAC inventory to provide world-wide support to the SR-71s. Being a KC-135A conversion, these aircraft are all equipped with the J57 turbojets. As an interim measure, they are being retrofitted with TF33-PW102 turbofans; when funding is available, they will be re-engined again with CFM56 high-bypass turbofans.

• KC-135R(1) – At various times during the 1960s and early 1970s, four KC-135As were converted to the initial KC-135R configuration. These varied greatly in detail, but all had a long, fence-like antenna on top of the fuselage. One became an RC-135T in 1971, one crashed, and two reverted to KC-135As. This configuration should not be confused with later KC-135Rs equipped with CFM56 engines.

• KC-135R(2) – Conversion of SAC KC-135As to the General Electric/SNECMA CFM56 engine started in 1984 and the programme has continued in increments as funding became available. By April 1988, 133 SAC KC-135As had been converted to KC-135Rs. It is SAC's intention to re-engine its entire KC-135A fleet with CFM56s. These are factory-new engines, not overhauled former airliner engines as in the KC-135Es. Because of the higher power, which permits a higher gross weight for take-off, and the reduced fuel consumption of the CFM56, the fuel-offload capability of the KC-135R is 50 per cent greater than that of the KC-135A.

•C-135FR – Starting in 1984, eleven of the French C-135Fs were refitted with 20,000 lb thrust General Electric/SNECMA CFM56 engines without

Retrofitting SAC KC-135As with CFM56 engines results in redesignation as KC-135R. This is the prototype with instrumented test boom on the nose. (*Courtesy Alain Pelletier*)

The elaborate electronics of the RC-135S include a Thimble nose and prominent Towel Rack antennae on the fuselage of former C-135Bs) (*E-Systems Photo P-10470-1*)

thrust reversers. The CFM56 installation makes the C-135FR identical to the SAC KC-135R.

• RC-135R – *see* RC-135T.

• RC-135S – The RC-135Ss were converted from ex-MAC C-135Bs. In general their appearance is similar to that of the RC-135M; however, on the forward fuselage, towel-rack antennae were added, one on the cargo door and up to three on the starboard side of the forward fuselage. Eventually, the upper towel-rack antennae on the right were replaced by large round windows, varying in number over time. The later configurations have a large sliding cover added for the windows. In 1972 some of the modifications resulted in the starboard upper wing-surface and inboard surfaces of the starboard nacelles being painted black for optical anti-glare purposes.

•TC-135S – In 1984, one AFSC EC-135B, which had served in the ARIA programme, was converted to the TC-135S to serve as a trainer for the RC-135S crews but does not carry the delicate avionics of the RC-135S.

• RC-135T – A single KC-135A was converted to the RC-135R in 1971, and then was further modified and redesignated RC-135T with a long fence-like antenna on top of the fuselage. The RC-135T was used in command support and training roles before reverting to a KC-135A.

Two RC-135Ss, modified from turbofan-powered C-135Bs. Note the extended Thimble nose and black-painted starboard wing. The inner sides of the starboard nacelles are also black. (*USAF Photo*)

Note the unusual location of US AIR FORCE on this RC-135V and that the blue SAC fuselage band does not extend over the white area of the fuselage. (*Photo courtesy A T Lloyd*)

• RC-135U – Three RC-135Cs were converted to RC-135Us in 1971. A single over-wing HF probe antenna was added to the starboard wing and the wingtips were modified to house additional antennae. A large, flat-bottomed antenna fairing was added aft of the standard nose and just ahead of the nosewheel doors. Large, flat-sided sensor fairing cheeks were added to the forward fuselage along with towel-rack antennae. The aft fuselage has been extensively modified to house additional antennae and sensors. A fuel-dump tube was retained from the original RC-135C configuration.

• RC-135V – Between 1973 and 1977, seven RC-135Cs and one RC-135U were converted to RC-135Vs. A thimble nose radome replaced the standard nose and the large, flat-sided fairings on the forward fuselage from the RC-135U were installed. Four large-chord, aft-swept blade antennae were added to the belly. In addition, the boom pod was replaced by a double-lobed antenna fairing. An integral static boom/pitot system was added to the wingtips, and an HF probe antenna was installed on the starboard wing.

• RC-135W – The six RC-135Ms were converted RC-135Ws. Subtle differences in the antenna configurations are the only discernible differences between these aircraft.

• TC-135W – In 1987, one former MAC C-135B was converted to TC-135W, similar to the RC-135W without the delicate avionics. The TC-135W serves as a trainer for the RC-135W crews.

Chapter 16

SMALLER JET TRANSPORTS, MODELS 727/737

Following the wide acceptance of the Boeing 707 and its rival the Douglas DC-8 as long-range transports and the appearance of the Boeing 720 on shorter routes, a demand developed for jet performance on still shorter routes and from airports that could not accommodate the 720. Boeing met this requirement with the new Model 727, which was then followed by the even smaller Model 737 for the shortest inter-city routes.

MODEL 727 – Studies for an entirely new short- to medium-range transport to serve routes uneconomical for the Model 720 were initiated in 1956 and achieved project status in 1959. In spite of the major configuration change, economy was achieved through extensive use of 707/720 equipment and components, notably the upper fuselage structure. Passenger accommodation on the first model, the 727-100, was 70 first-class or up to 129 tourist, or 28 first-class and 66 tourist in the mixed configuration. Flight crew was three. All 727s are equipped with hydraulically operated self-contained aft loading stairs and additional stairs can be installed forward of the cabin on the port side of the fuselage. Exceptional low-speed and short-field performance was obtained by use of new triple-slotted trailing-edge flaps, retractable leading-edge slats outboard of the taper break, and Krueger flaps inboard on the clean 32-degree-sweep wing.

View of Dominicana 727-2J1 HI-242 from below emphasizes the double taper of the 727 wing on both leading and trailing edges. (*Boeing Photo P-50465*)

The first Model 727, designated 727-22, on its first flight, February 9, 1963. Note full-span leading edge flaps. This is 727-22 for United Air Lines. (*Boeing Photo P-31279*)

Boeing did not originate the most noticeable feature of the 727 – the aft-mounted engine installation. Jet pods on the side of the fuselage were tried on the German Junkers Ju 287 bomber late in Second World War but were first used in regular production on the French Sud-Aviation Caravelle of 1955, which originated the aft location. This arrangement has three major advantages – increased ground clearance for the engine, reduced noise level in the cabin during take-off, and reduced trim problems with one engine inoperative. Several other manufacturers followed the French in adopting this arrangement. The use of a third engine installed in the aft end of the fuselage originated with the Martin XB-51 of 1948. Since it was desirable from the economy and reliability standpoints to use three engines on the 727, Boeing chose to cluster all three near the tail, two in pods and one under the vertical tail on the pattern developed for the British de Havilland

Normal entry for Model 727 is by means of self-contained aft airstairs. Photo at left shows special side installation developed for Eastern Air Lines' Model 727-25. (*Boeing Photos P-32710* and *P-32082*)

Model 727 was developed for operation from relatively small airports. Note extensive area of both leading and trailing edge flaps. (*Boeing Photo P-31702*)

D.H.121 Trident, a directly competitive aircraft. All three Pratt & Whitney JT8D turbofans, developed specifically for the 727, are fitted with thrust reversers but do not use sound suppressors. Special design features mix bypass air with the exhaust to reduce exit velocities and effectively reduce noise. The quiet operation of the 727 compared to larger jets enabled it to overcome the jet ban at LaGuardia and become the first jet to operate from that close-in New York terminal.

To eliminate the need for starting equipment at small airports, a gas-turbine in the right wheel-well of the 727 serves as an auxiliary power unit for starting, air conditioning, and other power requirements while the

Clamshell thrust reversers on the first Boeing 727. Note that side-engine units discharge vertically while the tail engine unit discharges horizontally. (*Boeing Photo P-31783*)

The prototype 727 in a fast run through a trough of water to prove that spray from the wheels will not be ingested by the engines. (*Boeing Photo P-35090*)

aeroplane is on the ground. Fuel capacity of 7,680 US gallons was enough to enable the 727 to cover a full route without having to refuel at any intermediate stops.

First flight of the 727 was on February 9, 1963, and ATC A3WE was issued on December 24, 1963. Initial 727 cost was $4,250,000, rising to an eventual $22 million in 1982.

The 727 had its size/performance field practically to itself and over a production life of 22 years became the world's highest-selling jet transport with 1,831 sold, displacing the 707 for that honour, although the 737 has now sold in greater numbers. Actually, 1,832 were built, but one remained Boeing property. One surprising feat of the 727 sales was a number of fleet replacement orders for 727s from early customers, some placed between 16 and 18 years after the initial orders. The last 727 was delivered in September 1984, but the first, a 727-22, was still in service with its original purchaser, United Air Lines, in October 1988. It is scheduled to be donated to the Seattle Museum of Flight in 1989.

However, in spite of intensive sales efforts, Boeing was unable to sell the Model 727 to the US Armed Forces. It was somewhat ironic, then, that the US Air Force should acquire retired airline 727-100s in 1983 and 1984, just

Lufthansa Model 727-30 carrying the airline-bestowed name of 'Europajet' for use on short European routes. (*Boeing Photo P-35114*)

Flight deck for three-member crew of a 727. The flight engineer's station is at the right behind the co-pilot. (*Boeing Photo P-52413*)

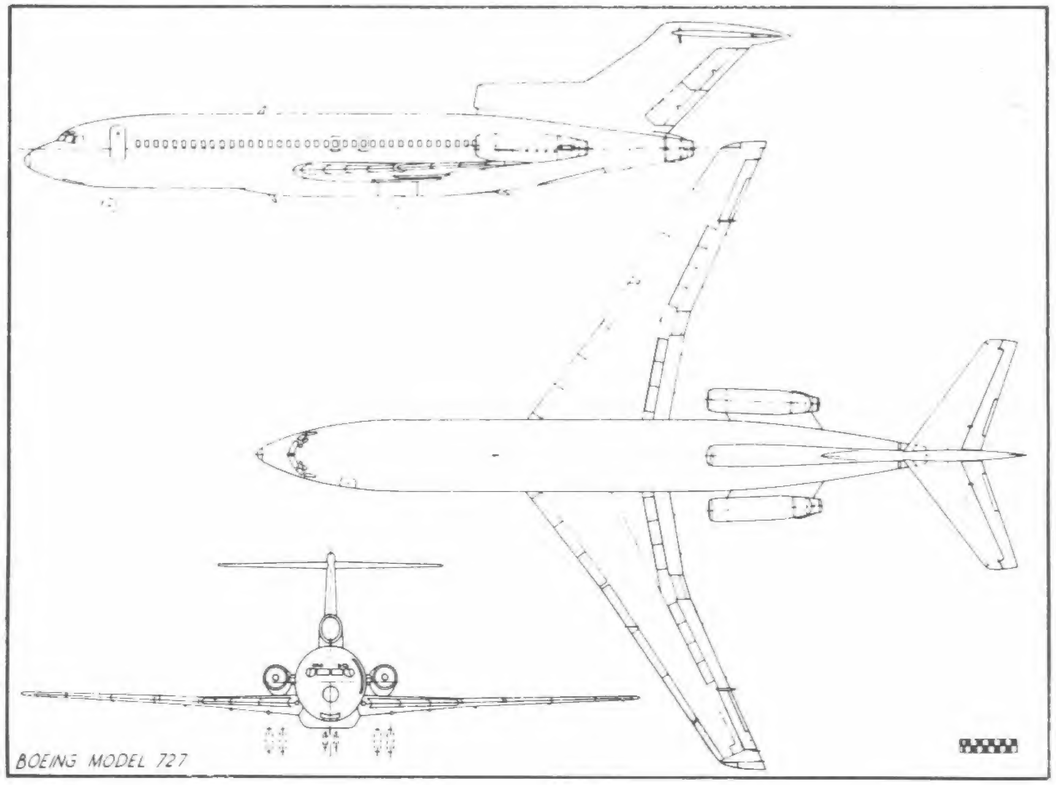
as 727 production was ending.

At the end of March 1988 the high-time 727 had flown 69,691 hr and the greatest number of landings by a 727 was 64,227.

MODEL 727-100 – This was a retroactive designation that became necessary after the lengthened Model 727-200 was put on the market in 1965. Initially, there were no 100-series numbers to identify the purchasers as with the 707. Two-digit identifications started with 22 for initial customer United Airlines. The numbers progressed to match the last two digits of previous customers for 707s and 720s, with new customers getting unused numbers in between. When the numbers reached 99, they continued into the 100s, the number now reflecting a true 727-100. In a few cases, early customers assigned two-digit identifiers, as American Airlines with 727-23s received later aeroplanes as 727-123s. In other cases, two-digit identifiers lower than the initial 727-22 were assigned. The last of 572 727-100s, a 727-1J1, was delivered in October 1972.

TECHNICAL DATA - MODEL 727-100

Type:	Passenger transport
Accommodation:	Maximum 131 tourist-class passengers
Power plant:	Pratt & Whitney JT8D-1, 14,000 lb thrust
Span:	108 ft
Length:	133 ft 2 in
Height:	34 ft



Wing area:	1,650 sq ft
Empty weight:	80,602 lb
Gross weight:	170,000 lb
Max speed:	632 mph
Cruising speed:	570 mph at 30,000 ft
Climb:	2,940 ft/min
Service ceiling:	36,100 ft
Range:	3,110 miles

MODEL 727-100C – In 1964 Boeing introduced a convertible passenger-cargo model with the gross weight increased to 169,000 lb. Principal difference from standard 727 was installation of a 7 ft 2 in by 11 ft 2 in cargo door at the forward end of the passenger compartment in the manner of the Model 707-300C. Quickly removable cabin equipment permitted change

Model 727-51C, the first convertible freight/passenger aeroplane for Northwest Airlines. Note the windows in the cargo door and the corresponding seats in the cabin. (*Boeing Photo P-39629*)

Window patterns were not symmetrical on the sides of the Boeing 727-100 series. The galley was on the right side of the cabin at the leading edge of the wing. This is Airlift International's 727-172C N732AL, which was leased to Braniff as N309BN. (*Boeing Photos P-43443 and P-43446*)

from all-passenger to all-cargo configuration. Northwest Airlines was the initial customer.

A typical passenger/cargo mix is 55 passengers and 22,700 lb of cargo, for which the range is 2,300 miles. An all-cargo load of eight pallets (38,000 lb) can be carried 1,700 miles.

MODEL 727QC – This is a dual-purpose 727 similar in appearance to the 727C since it has a cargo door located in the same position. However, to allow a more rapid conversion from one configuration to the other, the passenger facilities – seats, carpeting, galley, additional lavatory facilities, etc – are permanently installed on palletised floor sections that can be loaded into the fuselage with fork-lift trucks and mounted directly on top of the cargo floor. These sections are held in place by the regular cargo tie-down fittings. The rapidity with which the configuration change can be accomplished resulted in the designation of 727QC for quick change. However, no aeroplanes were built as QCs; the designation applies to 727-100Cs to which the pallet feature has been added by a kit. Initial orders for 35 kits were placed in April 1965 by United Airlines, Braniff, and Alaska Airlines.

MODEL 727-100F – No freighter versions of the 727-100 were sold as such. The designation applies to plain 727-100s retrofitted with cargo doors

In 1983 and 1984 the US Air Force acquired five Model 727-100s and designated them C-22A and B. This is a former Lufthansa 727-30. (*Douglas Slowiak photo courtesy David C Menard*)

and to some 727-100s and QCs with the passenger conversion option removed for use as dedicated freighters. These conversions were made for second-tier customers, in some cases, not the original purchaser.

USAF MODEL 727-100 (C-22) – In 1982 and 1983 the US Air Force arranged to acquire eight former airline 727-100s for the Air National Guard, but acquired only five. Four were former National Airlines 727-35s, originally built for National Airlines, designated C-22B and one was a former Lufthansa 727-30 that had been acquired by the FAA as N78 and released to the Air Force in 1984 to become the C-22A.

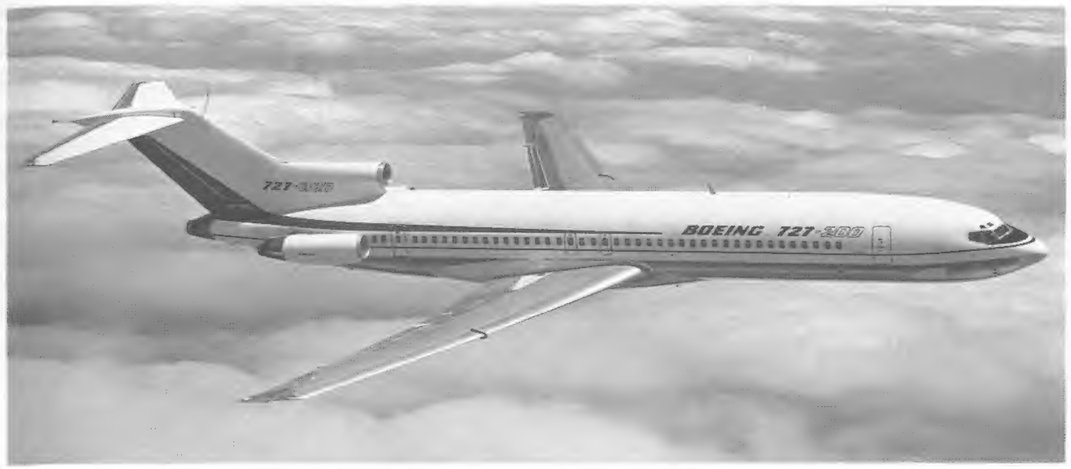
USAF serial numbers	*Boeing model*	*C/ns*
83-4610/4616	727-35	18811/18817 *
84-193	727-30	18362

*Only 83-4610, 4612, 4615, and 4616 were acquired. By design, the USAF serial numbers match former civil registrations N4610, 4612, 4615, and 4616.

MODEL 727-200 – The first flight of a stretched 727 designated 727-200, was made on July 27, 1967. Certification was received under the 727-100 type certificate on November 30, 1967, and Northeast Airlines became the first customer.

The length was increased by adding 10 ft fuselage plugs ahead of and behind the wing, which increased maximum passenger seating to 189. Initial power plants were the 14,500 lb thrust P & W JT8D-9, but improved variants up to JT8D-17 with 16,000 lb thrust were used later. Gross weight was initially the same 169,000 lb of the 727-100C, but increased over several years to 175,000 lb. Fuel capacity increased to 8,090 US gallons.

ADVANCED MODEL 727-200 – A further improved 727-200, this model had 17,400 lb thrust JT8D-17R engines and fuel capacity increased to a maximum of 10,520 US gallons through the use of auxiliary tanks. The gross weight increased to 209,500 lb. Range with 27,500 lb payload and 9,370 US gallons of fuel is 2,464 miles. The first Advanced 727 was delivered to All-Nippon Airways in June 1972. A major feature was



Prototype Model 727-200, which first flew July 27, 1967. Twenty-foot increase in fuselage length makes this model three inches longer than the 707-300 series. (*Boeing Photo P.41816*)

Northeast Airlines' 727-22 N1631 is an example of an airliner ordered by one airline but released to another before delivery. This was to have been United Air Lines' N7043U. (*Boeing Photo P-38575*)

Mexicana 727-264s were the only 727s approved for use of JATO during high-altitude and high-gross weight take-offs. (*Boeing Photo P-47078*)

View looking forward in the revised interior of the Advanced Model 727-200 with the 'wide body look'. (*Boeing Photo*)

extensive redesign of the passenger cabin to achieve a more modern appearance and greater passenger convenience.

The last passenger 727, a 727-264 for USAir, was delivered on April 6, 1984.

TECHNICAL DATA - MODEL 727-200

Type:	Passenger transport
Accommodation:	Maximum 189 tourist-class passengers
Power plant:	Pratt & Whitney JT8D-17, 16,000 lb thrust
Span:	108 ft
Length:	153 ft 2 in
Height:	34 ft
Wing area:	1,650 sq ft
Empty weight:	98,400–102,900 lb
Gross weight:	184,800–209,500 lb
Maximum speed:	Mach 0.90
Cruising speed:	599 mph at 27,400 ft
Service ceiling:	42,000 ft
Range:	2,800 miles (with typical load)

MODEL 727-200F – Only three 727-200s have been converted to side-door freighters by retrofit as have the 727-100Fs. These are former Air Canada 727-233s modified for Federal Express as follows: N218FE (ex-

Great ceremony attends the rollout of a new model, but Boeing celebrated the rollout of the last Federal Express 727-252F in September 1984. (*Boeing Photo K-50285*)

C-GAAM) c/n 21101, N219FE (ex-C-GAAN) c/n 21102 and N220FE (ex-C-GAAC) c/n 20934.

The final fifteen 727s built, and the last of 1,260 727-200s, were dedicated freighters from the start, having no provision for passengers and no cabin windows. Federal Express, the pioneering overnight package freight organization, which already had a fleet of 53 various used 727s, took delivery of its first 727-252F in June 1983 and the last in September 1984, to end 22 years of Model 727 production. The fifteen new Federal Express aircraft were N201FE, 203FE, 204FE/213FE, 215FE/217FE c/ns 22924/22938.

727 UDF – To test a new power plant for a proposed advanced-technology twin propeller-turbine transport, the Model 7-J-7, Boeing installed a proto-

Boeing acquired a used 727-63 for test purposes and used it for experimental installation of a General Electric unducted fan under consideration for a new 7-N-7 design. (*Boeing Photo P-59110*)

type General Electric GE-36 UDF (unducted fan) engine on a Boeing-owned 727. This unique engine, which drives contra-rotating pusher propellers, was mounted on the starboard side of the 727 fuselage in place of the standard P & W JT8D turbojet.

The GE-36 achieves significant weight reduction and a 45 per cent increase in fuel efficiency over equivalent (25,000 lb thrust) propeller-turbines by eliminating the traditional gearbox and shaft assembly between the turbine and the propellers and use of a very high bypass ratio of 36. The co-axial propellers, with very low aspect-ratio blades and small diameter, are mounted directly on turbine rotors. Varying the blade angle, which can go beyond the fully feathered position to reverse pitch, controls the engine speed and power output.

Flight testing of the new engine on the 727 was conducted between August 1986 and February 1987. As a result, General Electric is going ahead with production of the engine but Boeing is not committed to the Model 7-J-7, which would have two of the UDF engines at the rear of the fuselage.

The 727 used for the UDF trials was the 727-63 N32720, c/n 19846, formerly owned by Faucett in Peru.

MODEL 737 – A small twin-engined short-range airliner that achieved project status in November 1964 and was ordered into production early in 1965. A return to wing-mounted engines was dictated by the fact that passengers could not be seated alongside fuselage-mounted engines as used on the Model 727. Because of the smaller size of the aeroplane, a larger percentage of the total fuselage was needed for passenger seating. The passenger cabin of the 737-100 is only 10 ft 6 in shorter than that of the 727-100.

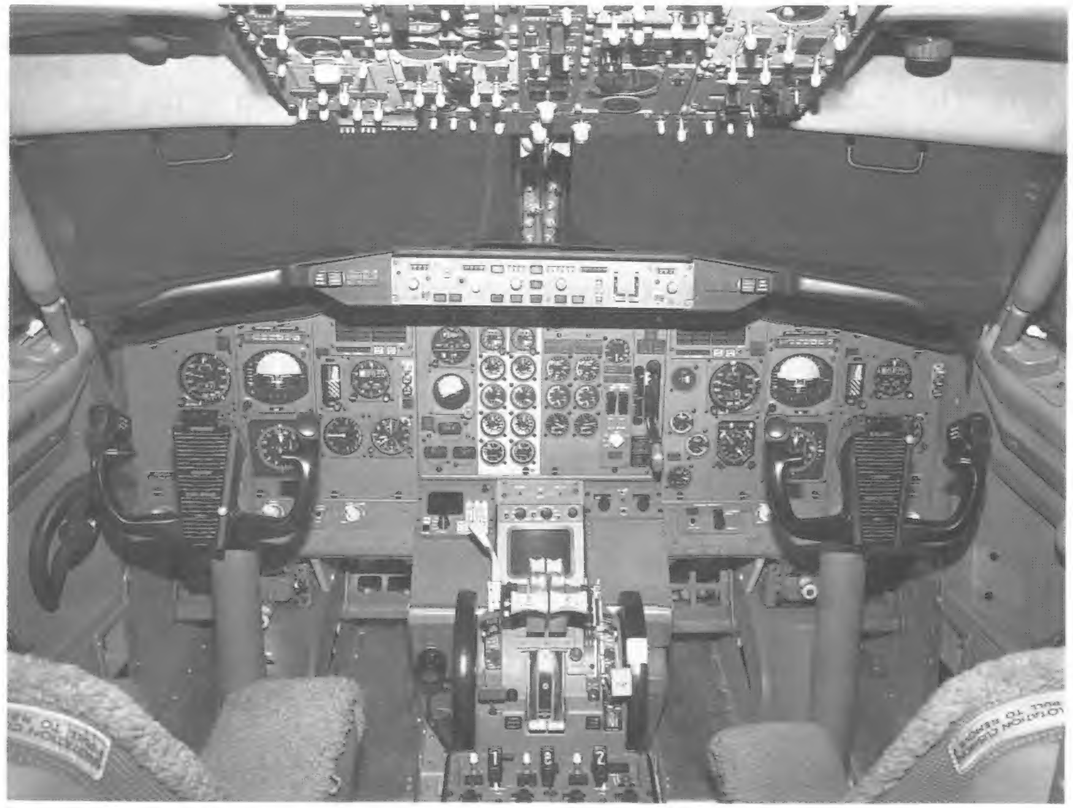
Also because of the aeroplane's small size and the problem of ground clearance, the same Pratt & Whitney JT8D engines used on the Model 727 could not be mounted on struts below the wing as on the Model 707. An

First take-off of the prototype Model 737-100, April 9, 1967. Ports at forward ends of nacelles open for increased air flow during take-off. (*Boeing Photo P-41201*)

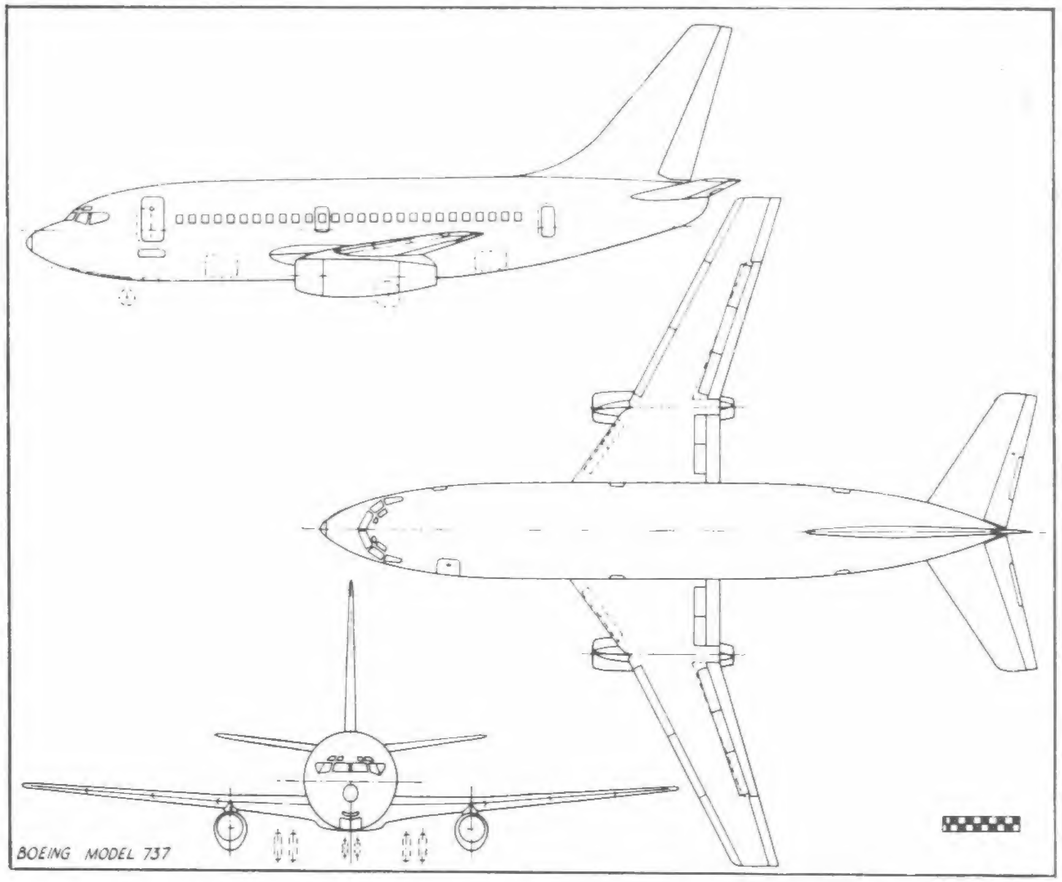
Prototype Model 737-100 in level flight with extra air inlets closed. Spots on lower nose are small insignia of all airlines that had ordered 737s to April 1967. (*Boeing Photo P-41216*)

outboard installation similar to that of the B-47 was adapted to the Model 737, with the engines mounted tightly against the underside of the wing in long thin nacelles.

The 737 derived most of its cabin and flight deck features from the 727 and the 707, and above the cabin floor it is virtually identical to these models, with a high degree of parts commonality. A standard feature on the



Two-crew flight deck of the Boeing 737. (*Boeing Photo*)



737 is self-contained air-stairs at the forward passenger door as on some 727s. The smaller 737 wing is virtually a scaled reduction of the 727 wing but with a quarter-chord sweepback of only 25 degrees.

When the Boeing Model 737 appeared, the competing Douglas DC-9 had been in service with a two-man flight deck crew. There was a major controversy at the time between the airline pilots union and the airlines over the question of two-man versus three-man crews for the new smaller jet-liners. The 737 was not built with a flight engineer's station, but some airlines insisted on a place for a third man who had minimal duties. Two-pilot crews (there are now quite a few female airline pilots) are now standard for 737s and even late model 747s.

The first flight of the first 737-100, a production aeroplane, was made on April 9, 1967, with certification for both the initial crew model and the lengthened -200 version being obtained in December.

The 737s originally were built in a new factory on the west side of Boeing Field half a mile south of Plant 2, but after 271 were completed, the production line was transferred to the Renton Plant, where it ran parallel to the 727 line, starting in December 1970.

Production of the 737 has continued through improved versions, the 737-500 being announced in May 1987. On June 12, 1987, it was announced that orders for the 737 had surpassed those for the 727 (1,831), making the

Lufthansa was the initial customer for the Model 737 with the 737-130. Note the short engine nacelles of the -100 series and the early -200s. (*Boeing Photo P-41706*)

737 the most ordered jet transport model in history. By the autumn of 1988, orders had reached 2,200. In view of continuing popularity, technical advances, and the cost of developing entirely new models, it is expected that production of the 737 will continue into the 21st century.

MODEL 737-100 – The 737-100 was a short-lived version, with only four customers. Lufthansa was the initial buyer, ordering 22. The company-owned prototype was a 737-130 in Lufthansa's configuration and was eventually sold to NASA. The 737-100 received Approved Type Certificate A16WE on December 15, 1967, and the last of 30 examples was delivered on November 2, 1969. The 1966 cost of a 737 was $3,200,000.

TECHNICAL DATA – MODEL 737-100

Type:	Short-range passenger transport
Accommodation:	99-107 passengers
Power plant:	Pratt & Whitney JT8D-7, 14,000 lb thrust
Span:	87 ft
Length:	93 ft 9 in
Height:	37 ft 1 in
Wing area:	922 sq ft
Empty weight:	56,893 lb
Gross weight:	93,500–111,000 lb
Cruising speed:	575 mph
Operating ceiling:	35,000 ft
Range:	1,150 miles

MODEL 737-200 – The 737-200 was the 737-100 lengthened by 6 ft to accommodate up to 130 tourist passengers at 28 in pitch. Power plants were 16,000 lb thrust Pratt & Whitney JT8D-9, -15, or -17 turbofans in new

First flight of the prototype Model 737-200, August 8, 1967. Doors are not a loose fit as implied by photo; new FAA safety regulations require all airliner exits to be heavily outlined for rescue purposes. (*Boeing Photo P-41862*)

'quiet' nacelles that suppressed jet noise. Gross weight increased to 107,000 lb and fuel capacity to 5,160 US gallons. First flight was on August 8, 1967, and the -200 was added to the 737-100 Type Certificate on December 21. United Airlines was the initial customer, taking its first delivery of 40 on December 29, 1967. The last of 1,114 737-200s was delivered in August 1988.

ADVANCED MODEL 737-200 – Starting with the 135th 737-200 in May, 1971, a new 'Advanced' version became the production standard. Range was increased to 2,370 miles with 115 passengers by reduction of aerodynamic drag, and the thrust reversers were replaced by a new target type, which added a noticeable 45-in extension to the rear of the nacelles. Maximum cruising speed increased to 576 mph at 22,600 ft and take-off weight increased to 115,000 lb. Kits for these changes were available for the upgrading of earlier 737-200s.

This view of 737-2A9C shows the extended engine nacelles of the 'Advanced' 737-200 and the exposed outer surface of the retracted main landing wheels. (*Boeing Photo P-46194*)

Model 737s with Gravel Kits installed have air blast tubes on the front of the nacelles. The gravel deflector on the nosewheel remains outside the fuselage when the undercarriage is retracted as on this 737-242C. (*Boeing Photo P-44624*)

A new feature developed for the 737-200 was a gravel runway kit. A gravel deflector plate was added behind the nosewheel, remaining outside the fuselage when the undercarriage was retracted. A small tube projecting forward from the bottom of each nacelle directs blast air ahead of the nacelle to break up the inward-rushing vortices that can suck gravel from the ground and force it into the jet intakes.

TECHNICAL DATA - MODEL 737-200

Type:	Short-range transport
Accommodation:	115–130 passengers
Power plant:	Pratt & Whitney JT8D-9A, 15,500 lb thrust
Span:	93 ft
Length:	100 ft 2 in
Wing area:	980 sq ft
Empty weight:	61,630 lb
Gross weight:	115-500-128,000 lb
Cruising speed:	575 mph
Service ceiling:	35,000 ft
Range:	2,136 miles

MODEL 737-200C – As with the 707 and 727, the 737-200 was available as a convertible passenger-cargo model, with a 707/727-size cargo door ahead of the wing. Up to seven pallets or containers can be carried in the all-cargo version, with the units loaded slightly off-centre toward the right side of the cabin, leaving passage room on the left. With only six pallets, room is provided for 11 passengers, and with two pallets 81 passengers can be carried at 32-in pitch.

The 737-200C was quite popular, with 44 customers ordering 104 examples. The first aircraft was delivered to Wien Consolidated on October 30, 1968.

MODEL 737-200F – No aeroplanes were built under this designation, but two Lufthansa 737-200Cs were stripped of passenger accommodation and

With bulk cargo carried forward, passengers on Wien Air Alaska Boeing 737-210C use the aft self-contained stairs. (*Boeing Photo K-39141*)

converted to pure freighters. These were D-ABGE and D-ABGH (formerly D-ABHE), c/ns 20257 and 20258.

MODEL 737-200QC – A quick-change option of the 737-200C is available with details similar to the 727QC. An experienced five-man crew can convert the aeroplane from passenger to cargo configuration in thirty minutes. The quick-change feature is identified by a Q-suffix to the aeroplane customer designation number.

MILITARY MODEL 737-200 – Purely military versions of the 737 were offered as 737M, and several were sold, but these were regarded simply as commercial sales to governments rather than to airlines. Details follow of two variants specifically outfitted for military missions by Boeing.

USAF T-43A – Nineteen specialized navigation trainers were ordered by

A navigation-trainer version of the 737-200 was built for the USAF as the T-43A. Note revised window spacing. The navigator's roof astrodomes have not been installed. (*Boeing Photo*)

Model 737-2X9 was built for the Indonesian government with side-looking radar on the upper rear fuselage. (*Boeing Photo P-56854*)

the USAF. These were basic 737-200 airframes with most passenger windows removed and the cabin arranged with up to 12 trainee-navigator stations, and four astrodomes on top of the fuselage. First flight was on March 10, 1973, with first delivery on July 31, 1973, and the last on July 19, 1974. Although the T-43As were built in a single block of Boeing c/ns, they were procured with Air Force funds from three separate fiscal years as reflected by their USAF serial numbers.

USAF serial number	*C/ns*
71-1403/1406	20685/20688
72-282/288	20689/20695
73-1149/1156	20696/20703

INDONESIAN AIR FORCE 737-2X9 – The Indonesian government ordered three 737-2X9s, which Boeing called Surveiller, for patrolling the extensive shorelines of the Indonesian Islands to detect illegal maritime activities. These were equipped with Motorola side-looking multi-mission radar (called Slammer) installed in distinctive housings above the rear fuselage. Deliveries were from May 1982 to October 1983.

Indonesian Air Force serial numbers:	AI-7301-7303
C/ns:	72777/72779

EXECUTIVE 737-200 – As with earlier models, Boeing offered deluxe non-airline versions of the 737-200, with greatly reduced seating but more luxurious appointments. For a brief period, 1985–1987, these were advertised as 'Corporate 77-32' before the designation was abandoned. Range could be extended to 4,606 miles by the addition of fuel cells in a lower cargo compartment.

While executive interiors were provided by Boeing, some customers preferred to use specialized contractors or skilled craftsmen in their own

The prototype 737-300, with sunlight picking out the dorsal fin. (*Boeing Photo P-58033*)

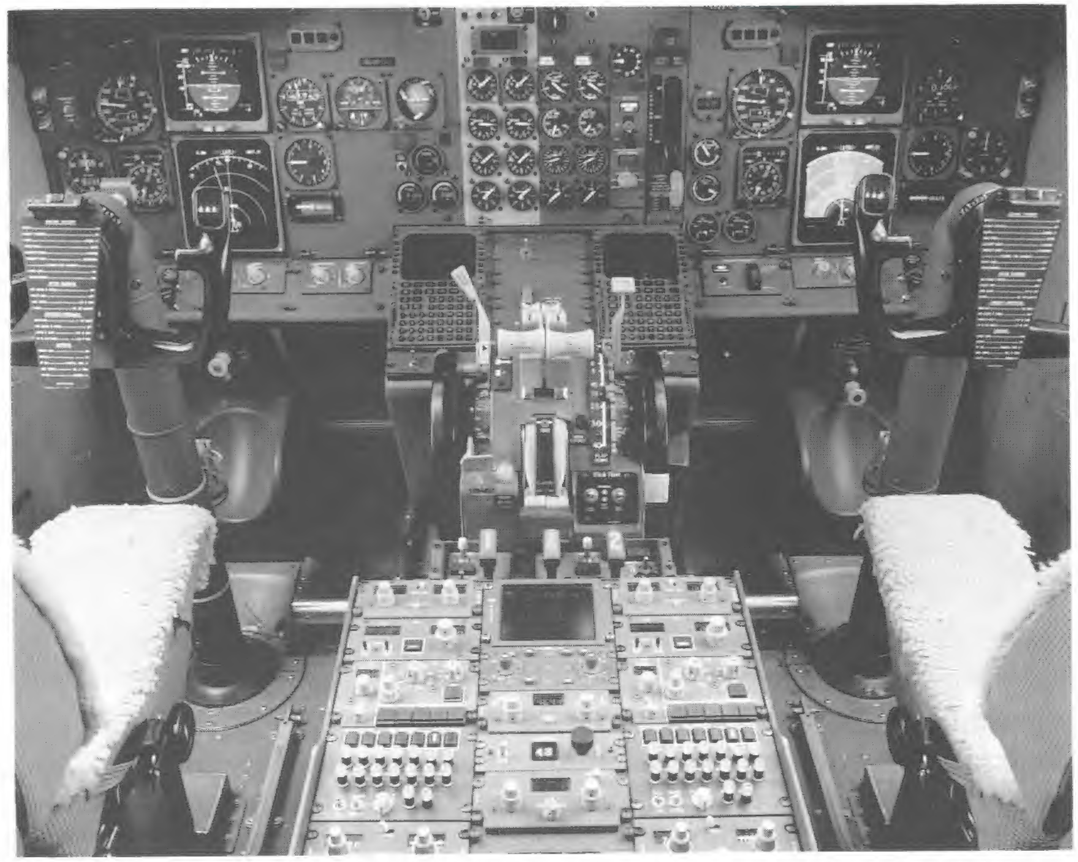
countries whose handiwork was more suited to the desired interior decoration than were commercial production efforts.

Aeroplanes delivered with or for conversion to such special interiors are sometimes identified in the designation by the suffix letter V. The following eight customers are known: Brazilian Government, Dome Petroleum, Eldorado, Essex, Maritime, Noga, Petrolair and the Venezuelan Government.

MODEL 737-300 – The 737-300 was put into production in March 1981 as a re-engined 737-200 with structural and aerodynamic improvements adapted from the Models 757 and 767. Flight deck instrumentation and passenger facilities are upgraded to 757/767 standards. The fuselage was lengthened 8 ft 8 in by adding a 3 ft 8 in plug ahead of the wing and a 5 ft plug aft of the wing. The wing span was increased 1 ft 10 in by an 11-inch extension to each wingtip. Seating was increased for up to 149 all-tourist passengers. The 737-300 was not intended to replace the 737-200 as the -200 had replaced the -100; it was a complementary design, with both models in production simultaneously for five years.

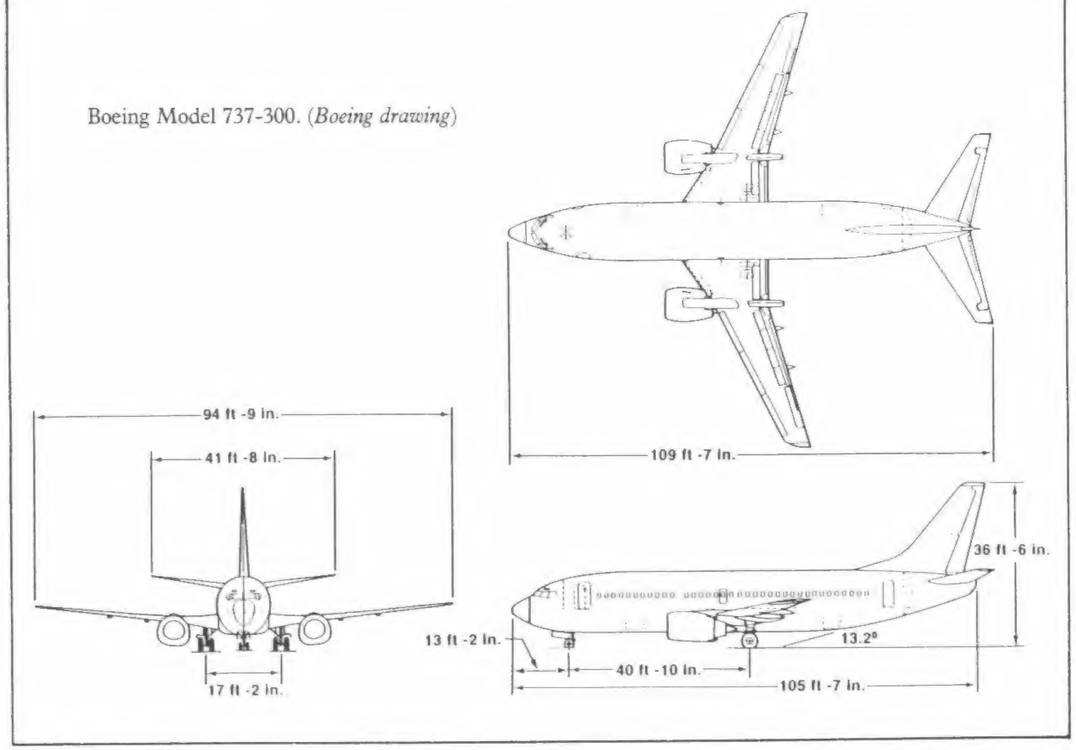
The most visible change is replacement of the original Pratt & Whitney JT8D engines with larger CFM-56 engines produced by CFM International (*see* 707-700). The larger diameter of the 20,000/23,000 lb thrust

The prototype 737-300 in a low-speed take-off test, showing the CFM56 engine entirely ahead of the wing. (*Boeing Photo P-57716*)



Flight deck of the Boeing 737-300 with EFIS CRT displays for both pilots. (*Boeing Photo K-53755*)

Boeing Model 737-300. (*Boeing drawing*)



When the larger CFM56 engines were installed in the Model 737-300, it was necessary not only to redesign the nacelles but to relocate certain engine components in order to obtain ground clearance. (*Boeing Photo P-57643-5A*)

high-bypass jets introduced ground clearance problems that were met by relocating accessories normally on the bottom of the engine to the side, flattening the bottom of the inlet lip and attaching the nosewheel unit 6 in lower. The new engines were moved entirely ahead of the wing and raised so that the top of the nacelle is even with the upper surface of the wing.

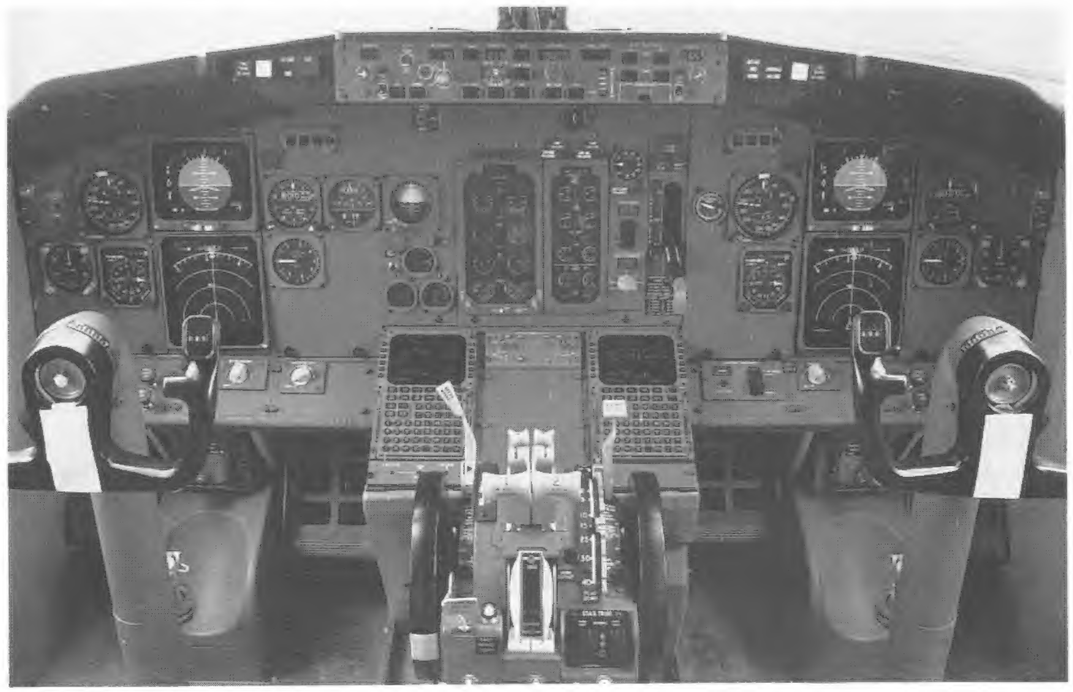
The lengthened fuselage increased mixed-class seating to 128 passengers or all-tourist seating to 141 at 32-in pitch. The increased length also required an extension of the lower portion of the vertical fin into a noticeable dorsal fin.

First flight of the 737-300 was on February 24, 1984, with certification under the 737-100 Type Certificate on November 14. Initial customer USAir took its first delivery of 97 on order on November 28.

TECHNICAL DATA - MODEL 737-300

Type: Passenger transport

USAir's 737-3B7 N351AU. (*Boeing Photo P-57536*)



Further refinement is apparent in the instrumentation of the 737-400. (*Boeing Photo H47068*)

Accommodation:	128–149 passengers
Power plant:	CFM56-3B1, 20,000 lb thrust
Span:	94 ft 9 in
Length:	109 ft 7 in
Height:	36 ft 6 in
Wing area:	1,135 sq ft
Empty weight:	69,400 lb
Gross weight:	124,500–139,000 lb
Range:	1,860 miles (with 141 passengers)

MODEL 737-400 – The 737-400 is essentially the 737-300 stretched to a length of 119 ft 7 in by adding a 5 ft 6 in plug ahead of the wing and a 4 ft plug aft. This increases the seating capacity for mixed class configuration to

This view of the prototype 737-400 shows the lengthened fuselage, longer engine nacelles, and extended wing leading-edge slats. (*Boeing Photo*)

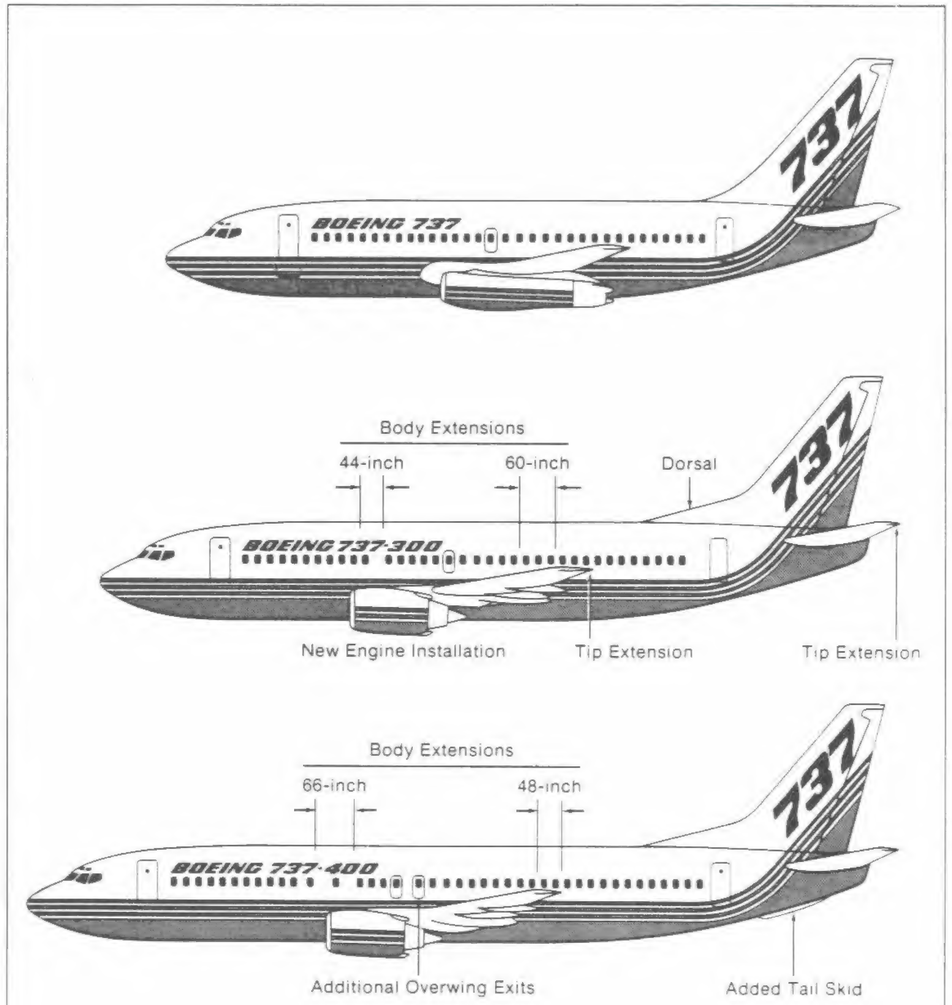
The first 737-400, bearing the registration N73700, its third use. This aeroplane was delivered to Piedmont Airlines as N404US. (*Boeing Photo K-55570*)

146, to 159 for all-tourist, and 168 in an inclusive-tour layout. The 737-400 is 26 ft 7 in longer than the original 737-100.

Gross weight has increased to 142,000 lb with the wing and undercarriage structure reinforced accordingly. Engines are the 22,000 lb thrust CFM56-3B-2 or the 23,500 lb thrust CFM56-3C. Initial customer was Piedmont Airlines (now taken over by USAir), which ordered 25. First flight was on April 29, 1988, with certification under the 737-100 Type Certificate on September 2. First delivery to Piedmont was on September 15, 1988, with entry into service on October 1.

By the end of September 1988 fourteen airlines and leasing companies had ordered 125 -400s, taken options on 47, and four had been delivered.

This view of the 737-400 clearly shows the shape of the engine nacelles. (*Boeing Photo P-59590*)



Model 737 growth. Top to bottom; 737-200, 737-300 and 737-400. *(Boeing drawing)*

TECHNICAL DATA - MODEL 737-400

Type:	Passenger transport
Accommodation:	146–170 passengers
Power plant:	CFM56-3B-22,000 lb thrust
Span:	94 ft 9 in
Length:	119 ft 7 in
Height:	36 ft 6 in
Wing area	1,135 sq ft
Empty weight:	73,700 lb
Gross weight:	138,500-150,500 lb
Range:	2,487 miles

MODEL 737-500 - This is essentially a replacement for the discontinued Model 737-200, using the same length fuselage as the 737-200 but the

equipment, systems, and CFM56 engines of the 737-300 and 737-400. The 737-500 was officially launched in May 1987.

By the end of September 1988 thirteen customers had ordered 133 -500s and taken options on a further 52. Roll-out was planned for May 1989 with first delivery in March 1990.

Chapter 17

THE MODEL 747

MODEL 747 – The 747 was facetiously named Jumbo Jet by the aviation press because of its unprecedented size, and the name stuck. The aeroplane is a logical expansion of the standard Boeing 707 configuration to a greater size to permit more economical operation through the reduction of seat-mile or ton-mile operating costs for the subsonic transport. This growth was relatively easy to achieve as no major breakthroughs were required in the structural or aerodynamic fields. It was not even necessary to add engines to obtain the necessary thrust increase as had so often been the case in enlarging past designs; the new Pratt & Whitney JT9D-1 of 41,000 lb thrust, soon followed by competing General Electric and Rolls-Royce designs, made it possible to remain with the four-engine configuration so that the 747 looks somewhat like an enlarged Model 707.

It is not as simple as that, however. With a wing span only 53 ft greater than the 707-300 and a fuselage 79 ft longer, the 747-100 weighs 376,000 lb more and, thanks to the wide body, carries over 200 more passengers. The greater weight called for greater wing span, but while a simple wing spanning well over 200 ft could have given the required results easily,

Although of the same general configuration, the Boeing 747 is not simply an enlarged Model 707. This photograph emphasizes the size and configuration differences. (*Boeing Photo P-44597*)

The pilots' cockpit of the 747 was raised above the top line of the fuselage to permit loading of bulk cargo through a hinge-up nose. (*Boeing Photo P-54344*)

Boeing recognized the problems such a great span increase would create with hangarage and airline terminals. The span of the 747 was kept as short as possible by maximum use of such high-lift features as triple-slotted trailing-edge flaps and full-span leading-edge Krueger flaps. For maximum cruising Mach number, the wing sweep was increased beyond that of the 707, to 37.5 degrees.

The carriage of oversize bulk freight was a consideration from the first, and the fuselage was designed to have the flight deck well above the eight-feet high ceiling of the forward cabin to permit straight-in loading through an upward-hinging nose. The top of the raised flight deck projects well above the top line of the fuselage, but rather than fairing it into the fuselage abruptly, the fairing was made long and formed the ceiling of an entire cabin. This was connected to the first-class section of the main cabin by a circular staircase. Some airlines used the upper deck cabin for a crew rest area or a first-class lounge while others fitted seats and windows for nineteen passengers. As this feature gained in popularity, the cabin was progressively extended aft to accommodate as many as 99 passengers.

Entry and evacuation procedures had to be revised, too. The five doors on each side of the main cabin are wide enough to allow two people to pass through abreast. Each is fitted with a pneumatic escape slide, including the doors over the wing that are normally used only in emergencies. For evacuation at sea, these slides become rafts.

The Model 747 was announced in April 1966, when it was revealed that Pan American World Airways had placed an order for 25. This order was contingent upon other airlines placing enough orders by a certain time to make production of the new model practical. However, the company was so confident of the market potential for the 747 that it began the construction of an entirely new factory at Everett, Washington, 35 miles north of Seattle, before the required number of orders was in hand. The number was soon exceeded and construction began, with the first example scheduled to roll out late in 1968.

The enormous capacity of the 747, between 363 and 490 passengers or 125 tons of cargo, required significant changes in normal loading and unloading techniques. The passenger version has five entrances on each side of the fuselage while the 'Combi' version has a cargo door on the left side aft

Top, original spiral staircase to the upper deck of the Model 747, and, lower, the latest straight staircase. There was also an intermediate right-angled stair. (*Boeing Photos 6A78826-23 and P-54961*)

of the wing. The freighter and convertible versions have a nose that hinges upward to permit straight-in loading on the main deck, with the side cargo door as an option. Baggage and additional cargo can be stored in cargo holds beneath the floor as on other Boeing jetliners. The main deck can be

Air view of the Everett plant, where the world's largest building by volume was erected for Model 747 manufacture. (*Boeing Photo EDC-34A-22-2*)

The unprecedented width of the 747 cabin provides two aisles and ten-abreast seating in a 3-4-3 layout. (*Boeing Photo P-45060*)

compartmented for varying passenger arrangements, with seating up to 10 abreast in the high-density seating versions. Two separate aisles are provided. Normal flight crew is three with up to 33 cabin attendants.

At the request of Pan American, the initial customer, the normal process of design growth was accelerated on the drawing board. The airline wanted more range than the 747 had been designed for, so Boeing obliged with the necessary changes to provide what was then unprecedented cruising range and left development of shorter-range versions for later.

When it appeared in 1969 the 747 was the largest and heaviest civil aeroplane ever built, and remains so at this writing, 20 years later. No termination of production has been scheduled and no larger replacement or competitor, either by Boeing or others, is known to be under development.

By September 1988, seven hundred and five 747s in nine different civil versions had been delivered out of 877 on order. Prices in 1967 were approximately $21,000,000, but by 1987 were approximately $107,000,000. By March 1988 the high-time 747 had 74,000 flying hours and the high-landing aeroplane had made 32,080 landings.

MODEL 747-100 – The initial version, with four Pratt & Whitney JT9D engines and accommodation for 66 first class and 308 tourist passengers, plus up to 60,000 lb of freight in the lower holds. There is one door for the forward hold and two doors for the aft hold. Later production 747-100s and early versions can by internal rearrangement carry up to 550 passengers.

The main undercarriage differs greatly from any used previously, and consists of four separate four-wheel trucks. Two trucks under the inboard wings retract inward. The presence of these wheels in the fuselage when retracted made it necessary to locate the two trucks mounted in the fuselage, and retracting aft, slightly aft of the wing trucks.

The first 747-100, which has remained Boeing-owned, was rolled out of the new Everett factory on September 30, 1968, and made its first flight on

This view of a Philippine Airlines 747-2F6B shows the positions of the sixteen main landing wheels at touchdown. (*Boeing Photo P-53919-15*)

February 9, 1969. Five aeroplanes were used in what up to that time was the most exhaustive pre-certification test programme ever undertaken for a civil aeroplane. Ten months and 1,400 hours of flying led to the award of Approved Type Certificate A20WE on December 30, 1969.

The 747-121 started commercial service with nonstop flights from New York to London on January 21, 1970. The JT9D engine, first flown on a special B-52, made its service debut on the 747. However, it did not enjoy the same smooth introduction to service as had the JT8D in the Model 727. Teething troubles with the JT9D resulted in many unscheduled engine changes during the first year of 747 operations.

As new features were adopted for later versions of the 747, such as the extended upper deck and side cargo doors, they became available for the 747-100 by retrofit. Such conversion work is done at Boeing Military Airplanes (so named since February 1988) in Wichita, Kansas.

The last of 167 plain 747-100s was delivered on July 12, 1976. One, Braniff International's single 747-127 N601BN, was, for a two-year period, accumulating flying time faster than any aeroplane in the world with a daily round-trip flight of 7,500 miles between Dallas, Texas, and Honolulu, Hawaii. Daily utilization was 14 hours, a figure never before attained by the airline industry. Some airlines have since increased daily utilization to 15 hr, and some have occasionally attained 500 hr a month with their 747s.

TECHNICAL DATA - MODEL 747-100*

Type:	Long-range transport
Accommodation:	374/490 passengers
Power plant:	Pratt & Whitney JT9D-3, 43,000 lb thrust
Span:	195 ft 8 in
Length:	231 ft 4 in
Height:	63 ft 5 in
Wing area:	5,500 sq ft
Empty weight:	348,816–370,816 lb
Gross weight:	710,000–735,000 lb

Braniff International's first 747-127 (N601BN) accumulated flying time faster than any aeroplane in history with daily 7,500-mile round trips between Dallas, Texas, and Honolulu, Hawaii. (*Boeing Photo P-47397*)

Maximum speed:	595 mph at 30,000 ft
Cruising speed:	640 mph (at low altitude)
Cruise ceiling:	45,000 ft
Climb:	2,000 ft/min
Range:	6,000 miles

*1970 version. General Electric and Rolls-Royce engine options and higher gross weights available later.

MODEL 747-100B – An improved 747-100 announced in September 1977, with reinforced structure, later series P & W JT9D engines, and options for several series of General Electric CF6 and Rolls-Royce RB.211 engines, features already incorporated in the pre-existing Model 747-200B. Allowable taxi weight increased to 753,000 lb. Initial customer was Iran Air.

To the detriment of accurate identification, it has been common practice to refer to both the 747-200B and the earlier 747-100B simply as 747B. Only those listed below appear in Boeing technical records as 747-100Bs.

Model	*Initial purchaser*	*Initial registration*	*C/n*
-146B	Japan Air Lines	JA8142, 8143	22066, 22067
		JA8164, 8170	23150, 23390
		JA8176	23637
-168B	Saudi Arabian Airlines	HZ-AIA/AIE	22498/22502
		HZ-AIG/AII	22747/22749
-186B	Iran Air	EP-IAM	21759

MODEL 747SP – The 747SP, for Special Performance, is another 747-100 variant sometimes referred to as a 747-100SP. It was developed for reduced passenger-mile cost on long-range flights. Much structural weight was saved by shortening the aft fuselage 48 ft 4 in. This was accomplished by reversing the normal stretch process of earlier jetliners by removing two straight sections of fuselage and one tapered section. The joining of the remaining aft fuselage sections resulted in a noticeable discontinuity of the previous fuselage lines. Shortening the fuselage reduced the cabin doors to four a side.

Major changes were made to the wings by replacing the original triple-slotted trailing-edge flaps with single units. The span of the tailplane was increased by 10 ft. Seating was reduced to 28 first-class passengers and 271 tourists on the main deck plus 32 passengers on the upper deck. Several versions of two power plants are available, General Electric CF6-45A2 or -50E2-F of 45,600 lb thrust or Rolls-Royce RB.200-524B2, -52422, or 524D4 with 50,100 lb or 43,100 lb of thrust. Fuel capacity was increased to 50,359 US gallons. Gross weight was reduced to 630,000/700,000 lb. The 747SP was certificated on February 4, 1976, and was added to the 747-100

The Model 747SP has the fuselage shortened by 48 ft, which noticeably alters the rear fuselage contours. This is Saudia's 747SP-68 HZ-AIF. (*Boeing Photo P-55071*)

Type Certificate under its own designation instead of being identified as a Short-Body 747-100.

Pan American World Airways, the initial 747SP customer, inaugurated nonstop service from New York to Tokyo in April 1976, and soon was achieving an average daily aeroplane utilization of 14.1 hr. On a delivery flight, a 747SP of South African Airways flew 10,290 miles nonstop from

The pilots' stations of the 747SP are similar to those of the 747-100. (*Boeing Photo P-51249*)

the Everett plant to Cape Town, a record for civil aircraft that still stands in 1988. In 1986 Pan American sold its trans-Pacific routes to United Airlines, which then took over Pan American's ten 747SP-21s plus one 747SP-27 that Pan American had previously acquired from Braniff.

On a special charter flight in January 1988 a Pan American 747SP flew around the world in an elapsed time of 46 hr 26 min. Actual flying time on the three-stage flight was 39 hr 26 min.

TECHNICAL DATA - MODEL 747SP

Type:	Long-range transport
Accommodation:	331–440 passengers
Power plants:	Pratt & Whitney JT9D-7A, 46,500 lb thrust
	General Electric CF6-45A2, 46,500 lb thrust
	Rolls-Royce RB.211-524B2, 50,100 lb thrust
Span:	195 ft 8 in
Length:	184 ft 9 in
Height:	65 ft 5 in
Wing area:	55,500 sq ft
Empty weight:	333,900 lb
Gross weight:	630,000–700,000 lb
Maximum speed:	619 mph
Service ceiling:	45,000 ft
Range:	7,658 miles (with 305 passengers, 20,000 lb cargo)

MODEL 747-100F – No Model 747-100s were built as freighters, but by the end of 1987 twenty-three had been converted to 747-100Fs.

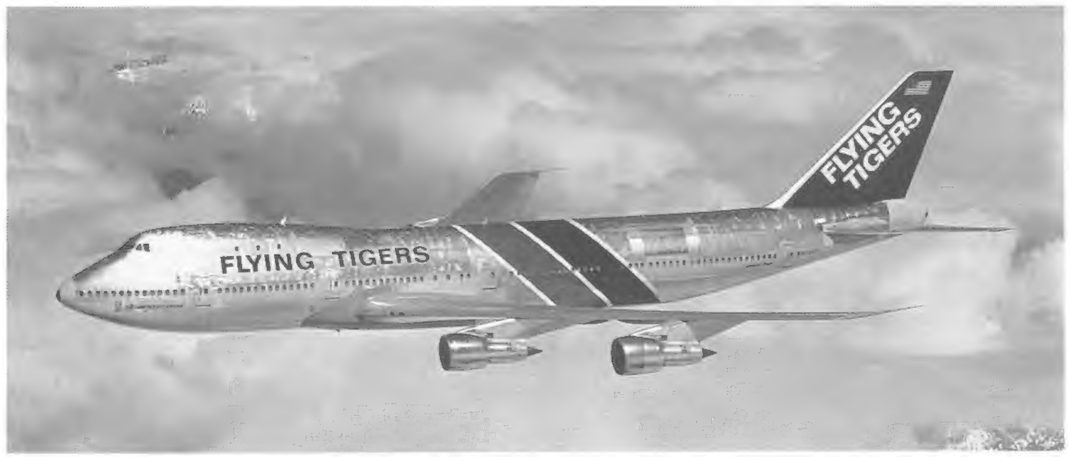
MODEL 747-100M – Another airline originated designation, this one by KLM to identify 747-100s in mixed freight/passenger configuration. No aeroplanes were built under this designation. The letter M indicated a Model 747-100 modified to add a cargo door on the left side of the fuselage behind the wing. The door is 11 ft 2 in wide and 10 ft 3 in high. To keep rain from running from the top of the fuselage into the open door, a rain deflector strip is installed above the door and projects several feet to each side. Boeing later adopted the letter to identify modified 747s, either with extended upper decks or side cargo doors.

The added door allows main deck combination, or 'Combi', loading; either all-passengers, all-cargo, or passengers and up to 12 pallets or containers. Containers up to eight feet high can be carried forward of the cargo door and containers 10 feet high can be carried aft of the door if the normal passenger ceiling is removed. Cargo and passenger areas are separated by a removable bulkhead, the passengers being seated forward of the cargo. The first 747-100 Combi was a Sabena 747-129 that was modified at Boeing-Wichita and redelivered to the airline in February 1974. No change of aeroplane designation was involved, nor does either the M or the Combi designation appear on the Type Certificate.

Rear cabin of a 747-100C with the ceiling removed. View looking forward. (*Boeing Photo P-51591*)

MODEL 747-100SL – This is not a Boeing designation, but was originated by Lufthansa in reference to its 747-100s that have been converted to side-door freighters. The letters SL indicate side loading. Boeing later added the letter M to identify such conversions.

MODEL 747SR – The letters indicate a special Short-Range version of the 747-100, in which the structure, particularly the undercarriage and its associated systems, has been modified to handle the added stress accumulated from a much greater number of take-offs and landings for a given number of flying hours. Passenger capacity was increased to 550 because fewer galley and lavatory facilities are required on short flights. Gross weight is reduced by the decrease in required fuel. Take-off weights



This 747-132 was delivered to Delta Air Lines in 1970, then was sold to Flying Tiger in 1978 and converted by Boeing to a 'Combi' with side cargo door aft of the wing. (*Boeing Photo P-51930*)

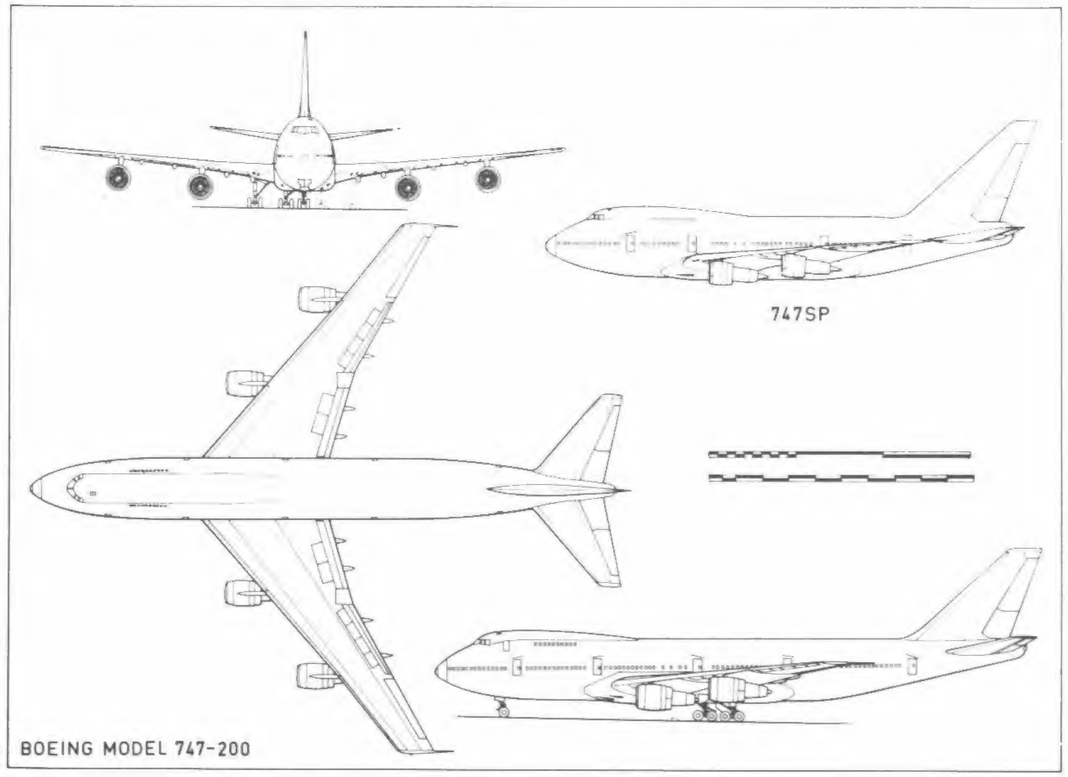
The Model 747SR is outwardly identical to the standard 747-100 but has reinforced structure for more frequent landings and has greater passenger capacity because of reduced galley and lavatory facilities. (*Boeing Photo P-48651*)

range from 520,000 lb to 735,000 lb. All three engine types are available for the 747SR.

Japan Air Lines was the initial customer, and placed 747-SR46s in service between Tokyo and Okinawa on October 7, 1973. Other 747SRs are used on shorter flights in the Japanese home islands.

MODEL 747-200B – Dimensionally similar to the 747-100 and having the same passenger capacity. There were no plain 747-200s; all had suffix letters, the first version being the -200B.

On November 12, 1970, a test 747-200B set a world heavyweight record by taking off at a gross weight of 820,700 lb. The 747-200B was certified on December 23, 1970, and added to the 747-100 Type Certificate.



The windows of Air-India 747-237Bs are not different to those of other 747s – the special colour scheme makes them look that way. (*Boeing Photo P-52826*)

In addition to structural reinforcement to sustain a gross weight of 775,000 and up to 820,000 lb and 52,409 US gallons of fuel, the 747-200B originally had the P & W JT9D-7R4-62 engines of 54,750 lb thrust. Two alternative power plants soon were available, the General Electric CF6-50E of 50,100 lb thrust and the Rolls-Royce RB.211-524-02 of 51,600 lb thrust. The installation of the CF6 engine was tested in the Boeing-owned 747-100 prototype before being incorporated in production aeroplanes. During testing of the first RB.211 installation, a 747-283B set a new weight record on November 1, 1976, at a gross weight of 840,500 lb. The normal range of a 747-200B with 442 passengers and baggage at a gross weight of 820,000 lb is 6,440 miles. Ferry range is 7,710 miles.

TECHNICAL DATA – MODEL 747-200B

Type:	Long-range transport
Accommodation:	Up to 550 passengers
Power plants:	Pratt & Whitney JT9D-74R4G2, 54,750 lb thrust
	General Electric CF6-50E2, 52,500 lb thrust
	Rolls-Royce RB.211-524D4-B, 53,110 lb thrust
Span:	195 ft 8 in
Length:	231 ft 10 in
Height:	63 ft 5 in
Wing area:	5,500 sq ft
Empty weight:	374,700–383,600 lb
Gross weight:	775,000–833,000 lb
Maximum speed:	610 mph
Service ceiling:	40,000 ft
Range:	7,940 miles (with 366 passengers and baggage)

MODEL 747-200B COMBI – Factory-built Combi version of the 747-200B with details similar to the 747-100M Combi. The 747-200B Combi is covered by the 747-100 Type Certificate but does not appear thereon as such. The first production 747-200B Combi was delivered to Air Canada in February 1975.

A Korean Air Lines 747-2B5B carrying a fifth (inoperable) engine under the port wing. (*Boeing Photo P-48945*)

MODEL 747-200C – The letter C here identifies a factory-built fully-convertible variant that can be configured for all-passenger, all-freight, or a combination load. A cargo distribution system is built into the main deck floor, and the passenger flooring is installed above the cargo rollers. Gross weight is 833,000 lb with either P & W JR9D-7R4G2 or General Electric CF6-50E2 engines. As on the 747-100 Combis, the passengers are carried forward of the cargo.

The 747 used as a freighter brought about a major revolution in the large-scale airlift of cattle. Previously, the animals had been walked singly up a ramp and into the aeroplane cabin, where they were tethered. Obsolescent aeroplanes, or others near the ends of their service lives, were usually used for this work because of the severe airframe corrosion resulting from animal wastes.

The 747, with its large cabin and side-door loading, changed this. The animals are now containerized. Up to six cows can be loaded into one leak-proof open-top container and lifted aboard. Up to 118 cows can be carried in a single 747.

The speed and range of the 747, even for trans-Pacific flights from the United States to the Orient via Alaska, make it unnecessary to unload the animals at intermediate stops, and thanks to the containers, the aeroplane is relatively clean at journey's end. The major change to a 747 Combi used regularly for cattle lift is an increase in the capacity of the cabin air conditioning system.

The first 747-200C first flew on March 23, 1973, was certificated on April 24, and delivered to World Airways on April 30.

MODEL 747-200F – A special freighter version of the 747-200 that was configured in the initial stages of 747 design. The major feature is straight-in loading of bulk cargo through a hinged-up nose hatch, called a visor by Boeing. The width of the cabin allows the loading of two rows of containers 8 feet wide by 8 feet high side by side. Some of these containers are intermodal, in that they are also used by railways and trucking lines interchangeably. The longest of these is 40 ft, and a 747-200F can carry six.

747 Freighters do not have windows on the main deck. Some have upper deck windows, as this Korean 747-2B5F, and some do not. This also has a side cargo door, which is hardly noticeable in photographs except for the rain deflector strip installed above it. (*Boeing Photo P-54243*)

An option is a side cargo door, and containers 10 feet high can be loaded through the side and carried in the rear part of the cabin. With no main-deck passengers, there are no main-cabin windows in the 747-200F; passengers can be carried on the upper deck, but this is not common.

The gross weight of a 747-200F varies from 785,000 lb to 820,000 lb depending on the particular engines used; three, with variations.

Distribution of the cargo as it is loaded is by means of a powered transfer system built into the cabin floor. With a central station at the nose door, two people can distribute and stow upwards of 250,000 lb of main-deck cargo in half an hour. An automatic weight-and-balance computer makes it unnecessary to manually calculate the weight and moment of each container. If the load is distributed beyond limits, the distribution system shuts down.

Cargo loading is normally by means of mobile ground equipment, but to serve airports without such facilities Boeing has developed an on-board cargo loader that is carried in the nose of the aeroplane. This can lift units of up to 30,000 lb through either the nose or side door. The 29-ft long unit,

In addition to its hinge-up nose cargo door, a characteristic of the 747F is the absence of cabin windows as on this Air France 747-228F (F-BPVR). The US registration N1783B, in very small figures, appeared on the rear fuselage during certification testing. (*Boeing Photo P-51554*)

Square cargo container loaded through the side cargo door of a Model 747-100C and fitting under the existing eight-foot high ceiling. (*Boeing Photo*)

which weighs 14,600 lb, is carried in the forward end of the cabin. It does not entirely displace cargo in that space because it can contain two 8 ft by 8 ft by 9 ft containers.

Range with a 242,000 lb payload is 3,570 miles. The first 747-200F was added to the 747-100 Type Certificate on March 7, 1972, and delivered to initial customer Lufthansa on March 10. Temporary US registration during certification testing on D-ABYE was N1794B (c/n 20373).

MODEL 747-200M – No Model 747-200Ms were built as such. The designation applies to 747-200Bs that have been modified to incorporate side cargo doors. By the end of 1987 sixty-five 747-200Bs had been converted to 747-200M.

The Boeing-designed On-Board-Loader can be used at airports without proper loading equipment, and can load either the nose or the side cargo doors. (*Boeing Photo WK-09621-13*)

Model 747-300 is essentially the 747-200 with upper deck extended to accommodate up to 91 tourist-class passengers. Earlier versions can be modified by extending the original short upper deck. (*Boeing Photo P-56422*)

MODEL 747-300 – A further variant of the basic 747-200. The significant change is extension of the upper deck to accommodate up to 91 tourist-class passengers. Main deck seating is increased by seven because of the new straight stairway, relocated at the rear of the upper deck. Existing 747-200 models can undergo the extended upper deck modification, which adds two emergency escape doors and slides, and can then be called 747-300s.

Flight testing began with two different engines, the JT9D-7R462 on October 5, 1982, and the CF6-50E2 on December 10. Certification under

The stretched upper deck of the Model 747-300 has greater capacity than the 1948 Model 377 Stratocruiser, with seating for up to 91 economy-class passengers. (*Boeing Photo*)

the 747-100 Type Certificate was obtained on March 7, 1983, and the first of nine for Swissair was put into service on March 28. Actually, this was a 747-357BC, a convertible. Swissair also ordered Standard 747-300s.

TECHNICAL DATA – MODEL 747-300

Type:	Long-range transport
Accommodation:	496 passengers (typical), 630 (maximum)
Power plants:	Pratt & Whitney JT9D-7R4G2, 54,750 lb thrust
	General Electric CF6-80C2B1, 55,640 lb thrust
	Rolls-Royce RB.211-524D4, 53,000 lb thrust
Span:	195 ft 8 in
Length:	231 ft 10 in
Height:	63 ft 5 in
Wing area:	5,500 sq ft
Empty weight:	383,400–393,500 lb
Gross weight:	775,000–833,000 lb
Max speed:	619 mph
Range:	7,710 miles

MODEL 747-300BC – The 747-300 is also available in a Combi version that retains the extended upper deck for passengers. The letter C in the designation identifies it as a Combi but the letter B, as used with the 747-200B but not the standard 747-300, is used as well. By September 1988, only Swissair had ordered the 747-300BC.

MODEL 747-300ER – Unofficially designated for the basic 747-300 with added fuel capacity to extend the range. By the end of 1987 only Japan Air Lines had ordered 747-300ERs, for use on nonstop Japan-USA flights.

The increased number of upper-deck passengers in the 747-300 required the addition of a door and escape slide on each side of the lengthened cabin. (*Boeing Photo H-45506-7*)

MODEL 747-300LR – Alternative unofficial designation for the basic 747-300 with added fuel capacity to extend the range. By the end of 1987 only Japan Air Lines had ordered 747-300ER/LRs for use on nonstop Japan–USA flights. The suffix designation does not appear in Boeing listings.

MODEL 747-300M – Model 747-200Ms with side cargo doors that have been further modified to extend the upper deck to 747-300 length, therefore qualifying them for the 747-300M designation. By the end of 1987 twenty-four had been so converted.

MODEL 747-300SR – Model 747-300 built with the features of the 747-SR. Japan Air Lines was the initial customer, with the first of four 747-346SRs delivered in December 1987.

C/ns: 23967, 23968, 24018, 24019
Registrations: JA8183, 8184, 8186, 8187

MODEL 747-400 – A greatly improved variant of the 747-300, with significant weight saving achieved through the use of new aluminium alloys and certain hardware adapted from the 757 and 767. Wing span has been increased by the use of 6 ft extensions on the wingtips. A notable feature of the new wingtips is the use of upward-pointing 6 ft-high winglets. The new wingtips increase the aspect ratio of the wing, thereby reducing induced drag and increasing the range of the aeroplane by a calculated three percent. To further increase range, by 400 st miles, an additional 3,300 US gallons of fuel are carried in new tanks in the tailplane.

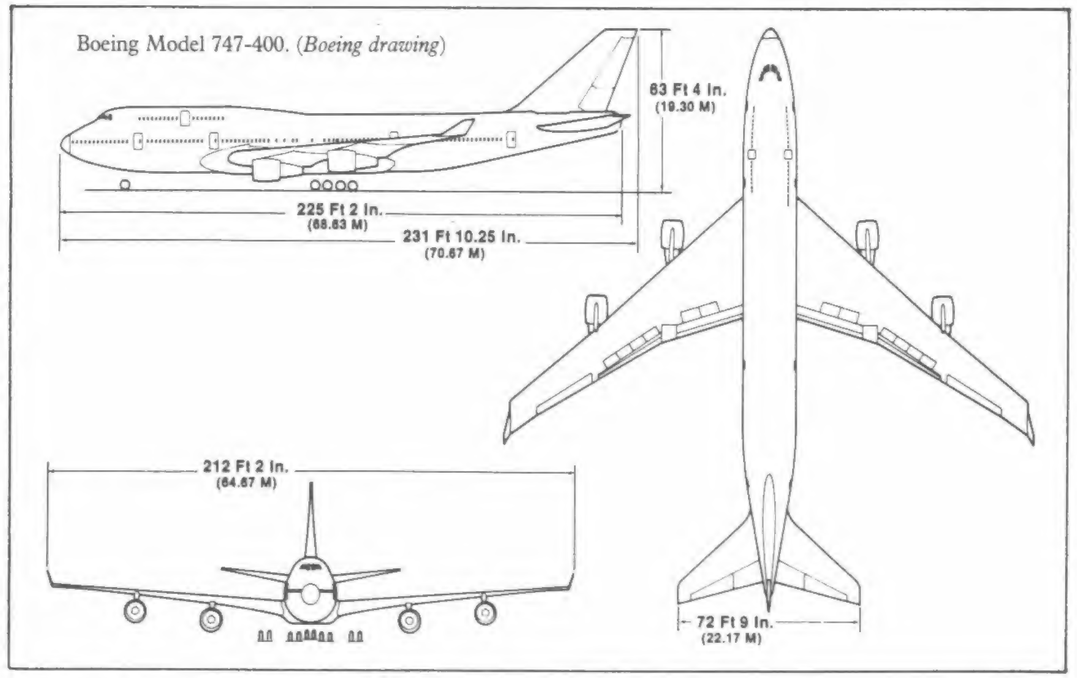
Three power plants, now in the 60,000 lb thrust range, are available, the CF6-80C2, PW4000, or RB.211-524G. New nacelles have been developed that are interchangeable with those of the 767. Flight deck and instrumentation improvements of the 757 and 767 have been adapted to the 747-400,

The first 747-400, showing the distinctive six-foot-high 'winglets' at the tips of the extended wing. The aeroplane was delivered to Northwest Airlines as N661US, but carried temporary registration N401PW to publicize the Pratt & Whitney PW4000-series engine. (*Boeing Photo P-59684*)

The two-pilot flight-deck for the Model 747-400. (*Boeing Photo K-55092*)

which now features a two-man cockpit.

The 747-400 flight deck design provides even more capability than the 757/767 design. Changes transform a three-crew-member, analogue cockpit



with electro-mechanical instruments to a full digital, two-crew flight deck with cathode ray tube displays.

Six 8 by 8-inch (200 by 200 mm) cathode ray tubes (CRTs) are used to display aeroplane flight control, navigation and engine and crew alerting functions. The larger CRTs allow more information to be displayed with a reduction in the number of conventional instruments. The number of flight deck lights, gauges and switches has been reduced from 971 to 365 on the -400, 22 fewer than the twin-engine 757/767 and 100 less than the 737 twinjet. Work load is designed to be one-half to one-third that of the standard 747.

Automatic or manual display switching is used as backup in the event of an individual CRT failure. The engine indicating and crew alerting system (EICAS) can call up the status or schematics of various systems at any time on one of the CRTs.

Depending on engines and other variables, the gross weight of the 747-400 ranges from 800,000 to 850,000 lb with an option offered for 870,000 lb. Thanks to the added fuel, more fuel-efficient engines, and the new wingtips, the 747-400 has a range of up to 8,400 miles. With PW4256 engines, 412 passengers and baggage, and required fuel reserves, the range is 7,945 statute miles.

On June 27, 1988, the first 747-400, a -451B for initial customer Northwest Airlines but temporarily registered N401PW to publicize the PW4000 engine, set a new official weight record by reaching an altitude of 2,000 metres at a gross weight of 892,450 lb.

The 747-400 was added to the collective Model 747 Approved Type Certificate on January 10, 1989. However, that does not mean that pilots qualified on earlier variants can immediately step into the -400 and fly it. Because of the great differences in the two-crew cockpit and the revised instrumentation, crews must be trained and qualified specifically for the -400. The first delivery was early in 1989.

TECHNICAL DATA - MODEL 747-400

Type:	Long-range transport
Accommodation:	496 passengers (typical), 630 (maximum)
Power plants:	Pratt & Whitney 4256, 56,000 lb thrust
	General Electric CF6-80C2B1F, 57,900 lb thrust
	Rolls-Royce RB.211-524G, 50,000 lb thrust
Span:	211 ft 5 in–213 ft*
Length:	231 ft 10 in
Height:	63 ft 5 in
Wing area:	5,650 sq ft
Empty weight:	391,000–393,000 lb
Gross weight:	800,000–870,000 lb
Max speed:	612 mph
Range:	8,406 miles

*Wing stretches when fully fuelled.

The 747 prototype was demonstrated as a military tanker, and is shown here in a simulated refuelling of a Lockheed SR-71. (*Boeing Photo 2PB-24764*)

MODEL 747-400M – A Combi version of the 747-400. KLM was the initial customer, ordering four with CF6-80C2 engines in April 1986, for delivery starting in February 1989. Three other airlines have also ordered 747-400Ms. Altogether, 21 airlines had ordered a total of 161 Model 747-400s by the end of September 1988.

MILITARY 747s

From the start, Boeing sought to interest the military in suitable adaptations of the 747. The prototype was even fitted with a Boeing flying refuelling boom and used for demonstration dry refuellings of high-performance USAF aircraft, but no tanker orders resulted. Other variants, as described here, were sold, however, as well as some tanker conversions of former civil airliners to other countries.

The first of three USAF E-3As in white and blue colouring. (*Boeing Photo V-0658*)

USAF E-4 SERIES – Known as Advanced Airborne Command Posts, the E-4s are logical successors to the various KC/EC-135 aeroplanes used as flying command posts. The greater capacity of the 747 allows the carriage of more equipment and a larger battle staff plus built-in 'hardness' features designed to protect the aeroplane and its equipment from the effects of nuclear blasts. The E-4s are painted white all over with blue speed stripes.

Exact cost figures are not available, but it is reported that the cost of a single E-4A is $150,000,000; $75,000,000 for the basic 747-200 aeroplane and a like sum for the special equipment and features.

• MODEL E-4A – The first of three E-4As, using the basic 747-200B airframe with JT9D engines, flew on June 19, 1973, and was delivered to the Air Force on July 16, after which much of the classified equipment was installed. The third was delivered with CF6-50E engines. Later, all three were upgraded to E-4B standard, with the first redelivered to the Air Force on July 15, 1983.

C/ns:	20682/20684
USAF serial numbers:	73-1676, 1677, 74-787

• E-4B – A fourth aeroplane on the original E-3A order but incorporating many refinements, such as additional generators for increased electrical capacity for the equipment and a larger battle staff. The E-4B has increased internal fuel for missions up to 12 hours' duration but can also be refuelled in flight.

As first delivered, the E-4B was outwardly indistinguishable from the E-3As, but when Super High Frequency (SHF) radio was added, a large and distinctive housing was added to the top of the fuselage at the rear of the upper deck. At the opposite end of the radio frequency range is Very Low Frequency (VLF) equipment requiring a five mile trailing-wire aerial.

Most of the functions that can be performed in the air relative to communication with ground facilities throughout the world can be performed while the aeroplane is on the ground when appropriate connections are made to the aeroplane.

The first Boeing E-4B built as such, with added Super High Frequency radio housing atop the fuselage. The three E-3As were upgraded to E-4B standard. (*Boeing Photo P-52809*)

The first flight was on April 23, 1975, with delivery to the Air Force on August 4, 1976, with less than full equipment. This was added over several years by organizations under contract to the USAF Oklahoma City Air Logistics Center. The fully-equipped E-4B was redelivered to the Air Force on December 21, 1979.

USAF C-SERIES – In addition to the electronic role of the E-4 series, the 747 serves the USAF in two notably different transport roles.

• C-19A – To provide the USAF with a ready reserve of heavy-lift transports in times of national emergency, the Air Force contracted with Pan American World Airways to modify 19 of its 747s with side cargo doors, reinforced main-deck flooring, and a cargo distribution system. This in effect made them into 747 Combis.

Although returned to airline passenger service in airline livery, these aeroplanes are now part of the US Civil Reserve Air Fleet (CRAF). The modifications add 13,000 lb to the empty weight of the aeroplanes; the Air Force compensates the airline for the corresponding reduction in payload.

The first C-19A conversion was completed and the aeroplane returned to the airline on May 31, 1985. The C-19A designation applies only when CRAF is activated. Air Force serial numbers are not assigned to the 747/C-19As.

• C-25A – To replace the two VC-137Cs that have served as Presidential aeroplanes since 1962 and 1972, the US Air Force ordered two 747-2G4Bs under the designation C-25A. As previously, the Presidential C-25As will have interior appointments, including two galleys, an emergency medical facility, self-contained airstairs, and world-wide communication capability. Normal accommodation is for 70 passengers and 23 crew members. Power plants are CF6-80C2B1s with 56,750 lb thrust.

C/ns:	23824, 23825
USAF serial numbers:	86-8800, 8900*

*These numbers were changed by special order to 82-8000 and 92-9000 to create a series following the two VC-137Cs 62-6000 and 72-7000.

IRANIAN AIR FORCE 747 – In 1975 the Imperial Iranian Air Force (later Iranian Islamic Air Force) acquired twelve used 747 airliners and had the then Boeing Military Aircraft Company in Wichita militarize them. Five were 747-131s, purchased from TWA, three were ex-Continental Airlines 747-124s, and four were 747-125s that Eastern Air Lines had bought from Boeing but had immediately sold to TWA. While at Wichita, all were fitted with side cargo doors and three with Boeing in-flight refuelling booms.

These received three-digit IIAF serial numbers preceded by the figure 5. In 1976, these were all replaced by four-digit numbers prefixed by 5. In 1977 and 1978, the IIAF bought four additional 747-2J9Fs new from

The first eight Iranian Air Force 747s were former civil airliners converted to military configuration, including in-flight refuelling capability and side cargo doors, by the Boeing Military Aircraft Company. (*Boeing Photo P-52574*)

This 747-125 was delivered to Eastern Air Lines, sold to TWA, and then resold to Iran. Militarized by Boeing and fitted with Boeing flying boom. This is an excellent view of the triple-slotted wing flaps of the 747. (*Boeing Photo P-51909*)

A former American Airlines 747-123 was acquired by NASA and modified by Boeing to serve as the shuttle carrier aircraft, SCA. (*Boeing Photo*)

The 747 SCA enters a shallow dive to launch the unpowered space shuttle into free gliding flight. The auxiliary tailfins of the 747 are used only when carrying the shuttle. (*Boeing Photo R-1288*)

Boeing and assigned continuing four-digit serial numbers. In 1984 all but three of the IIAF 747s were given civil registrations.

NASA SHUTTLE CARRIER - In 1974 the National Aeronautics and Space Administration (NASA) obtained a 747-123 from American Airlines. After using it for wake vortex investigation, it was sent to Boeing in 1976 for

Twenty years of the 747. On September 30, 1988, Boeing pilots flew the first 747-100 over Seattle in company with the first 747-400, the 735th 747 built. The occasion was the 20th anniversary of the rollout of the first Model 747. (*Boeing Photo by Ken Dejarlais*)

modification as a carrier for the forthcoming Space Shuttle and subsequently designated Shuttle Carrier Aircraft (SCA).

The aeroplane was stripped of all airline equipment, but the original American Airlines red, white and blue striping was retained. The fuselage was reinforced to support the weight of the 150,000 lb shuttle and removable end fins were added to the tailplane to improve directional stability when carrying the shuttle. The JT9D-3A engines were modified to JT9D-7AH standard to increase the take-off thrust to 46,900 lb.

Two missions were envisioned for the SCA – carrying the shuttle aloft for initial aerodynamic testing, followed by launch into free-gliding flight, and ferrying of the shuttle from the US west coast, where it is built and where it usually lands, to the launch site at Cape Canaveral in Florida.

The shuttle is mounted on top of the SCA by being hoisted under an overhanging gantry, after which the SCA is wheeled into place beneath it. The shuttle is then lowered into the cradles on top of the SCA.

Initial taxiing tests of the combination began early in February 1977. The first flight, with the shuttle unmanned and not to be released, was made on February 18. Gross weight of the combination was 584,000 lb on all but the last two captive and free-flight tests. The three rocket motor nozzles of the shuttle were covered by a Boeing-built fairing.

Launch procedure for the shuttle called for the SCA to enter a shallow dive. When the necessary airspeed was attained the crew of the shuttle released the latches and lifted free of the SCA. When the shuttle is ferried to Cape Canaveral, it is unmanned and remains aboard for the landing.

C/n:	20107
Registration:	N905NA (ex-N9668)

Chapter 18

MODELS 757 AND 767

The Boeing Models 757 and 767 began as two completely separate lines of development but ended having such a high degree of commonality in spite of their size differences that a pilot who qualifies in one model is automatically qualified on the other.

Both designs were the result of the great increases in the cost of jet fuel in the mid-1970s and the subsequent demand by the airlines for more fuel-efficient aeroplanes. In 1973 jet fuel cost $0.11 a US gallon; by 1974 the price had increased to $1.10, but has dropped to about fifty cents since. It was much more expensive in many other parts of the world. Developing a new model is a long and costly project for any aircraft firm, so Boeing's simultaneous development of two separate models was an unprecedented move in the jet-era of commercial aviation as well as an enormous financial undertaking.

In spite of the sequence of model designations, the debut of the Model 767 preceded that of the Model 757 by five months.

It is interesting to note that the fleet-wide average of flying hours to landings for both the 757 and the 767 is higher than for previous models because so much of the pilot training is now done in simulators rather than in the aeroplane.

Two prototypes together. The new Boeing Model 757 and 767 prototypes fly side-by-side for this early 1982 portrait. Other than size, the distinguishing features are fuselage fineness and nose contours. (*Boeing Photo*)

MODEL 757

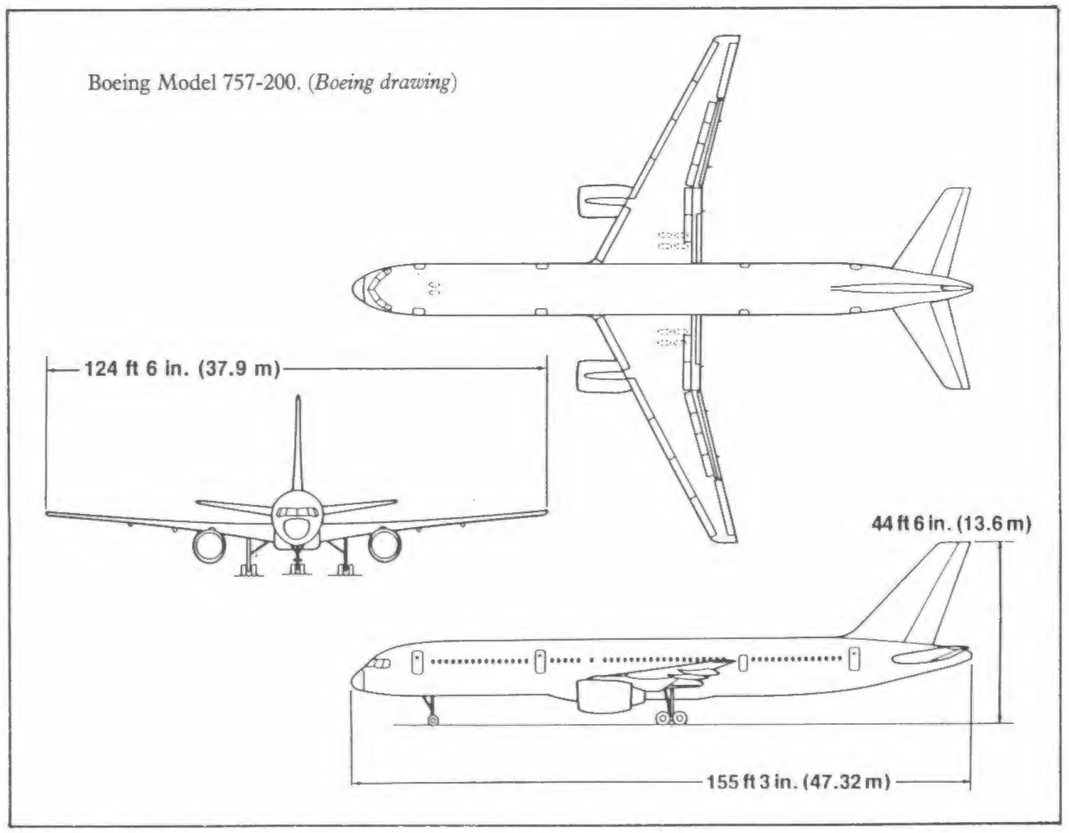
This 186/228-seat twinjet was originally to have been a greatly refined Model 727 designated 727-300. After extensive design work and tentative airline orders that did not materialize, the 727-300 concept was abandoned. The new model that became the 727 replacement was designated Model 757 and initially was planned to use many 727 structural and design features including the high-mounted tailplane, main fuselage, and flight deck. The major change was to a new-technology wing with 25-degrees sweep and two wing-mounted engines rather than three engines near the tail. For a fuselage only three feet longer than that of the 727, the relocation of the side engines allowed a longer passenger cabin and more passengers in the same single-aisle six-abreast seating arrangement as the 727.

As design studies progressed the Model 757 got further and further from Model 727 detail and took on more features of the Model 767 that it already resembled because of the two wing-mounted engines. The T-tail was abandoned in favour of a dihedral tailplane on the centreline of the fuselage as on the Model 767. The Model 757 was designed from the start for a two-pilot flight deck and again, as design progressed, this took on more detail of the 767 and less of the 727.

Improved aluminium alloys and such new structural materials as graphite

The two-pilot flight deck of the Model 757. (*Boeing Photo*)

View looking aft in a Model 757-200. (*Boeing Photo*)



Boeing Model 757-200. (*Boeing drawing*)

composite and Kevlar, adopted for late-production versions of earlier Boeing jetliners, were designed into the 757. The aerodynamics of the wing were greatly improved but the established control system of outboard and inboard ailerons, trailing-edge flaps split behind the engines, and full-span leading-edge Krueger flaps were retained. A single main undercarriage unit in each inboard wing carries a four-wheel truck which derives from the Model 707.

The initial power plant was the 37,400 lb thrust British Rolls-Royce RB.211-535C, a good example of offset since British Airways, which ordered 19, with an option for 18 more, was one of the two initial 757 customers. Alternative power plants are the 38,200 lb thrust Pratt & Whitney PW2037 and a more powerful 2040. A 40,100 lb thrust Rolls-Royce RB.211-535E4 became available and is now the type most chosen. Engine reverse thrust on the 757 with Rolls-Royce RB.211 engines is unique; the rear portion of the outer nacelle skin slides rearward to expose thrust-reverser vanes inside the nacelle.

The great external similarity of the 757 and 767 presents a recognition problem. Principal details that distinguish the 757 from the larger 767 are the noticeably slimmer fuselage and a nose with its point considerably lower than on the 767 and all previous Boeing jetliners except the 747, and the four very prominent flap track fairings under each wing.

The first Model 757-200, Boeing-owned for use as a prototype and development aeroplane, rolled out of the Renton factory on January 13, 1982, and was soon joined in the test programme by four others. First flight was on February 19, 1982. The US Approved Type Certificate A2NM was awarded on December 21, 1982, and British approval was obtained in January 1983.

As with previous Boeing jetliners, the Model 757 soon appeared with different configurations, including a Combi passenger/freight version and a stripped Package Freighter version.

The Boeing-owned Model 757 prototype, N757A, designated 757-225, was fitted with Rolls-Royce engines. Note engine nacelles opened for thrust reverser action. (*Boeing Photo P-55738*)

This take-off photograph of the 757-225 with Rolls-Royce RB.211 engines shows flap configuration and the four-wheel undercarriage trucks derived from the Model 707. (*Boeing Photo P-56274-8A*)

By September 30, 1988, ninety-one Model 757s had been delivered out of 368 ordered. By that time the high-time aeroplane had 20,196 flying hours and the high-landing aeroplane had made 16,833 landings. The initial price of the Model 757 was $35,000,000, rising to a 1988 range of $42 to $48 million.

MODEL 757-200 – The series designations for the Model 757 began with 200 rather than 100. The initial configuration, with either Rolls-Royce or Pratt & Whitney engines, has passenger capacity ranging from 187 to 228. In mixed class, the most common arrangement is 16 first-class passengers in the forward cabin with 38-in pitch between seat rows and 187 tourist passengers in the main cabin at 32-in pitch for a total of 203 passengers. Seat pitch can be squeezed down to 29-in to carry 228 all-tourist passengers, but such condensed seating requires the installation of one additional overwing escape hatch on each side of the fuselage.

The 757 differs from other narrow-body (or single-aisle) Boeing jetliners in having either two or three passenger entry doors on each side of the cabin, the third door amidships being an option, instead of the customary two only on the left side. Doors for the two lower cargo holds ahead of and behind the wing are on the starboard side of the aeroplanes

The first flight of a 757 fitted with Pratt & Whitney engines was on March 14, 1984, and the variant was included in the same Approved Type Certificate issued to the Rolls-Royce powered version. The first delivery, a 757-225 to Eastern Air Lines, was on December 22, 1982, with commercial service inaugurated on January 1, 1983.

TECHNICAL DATA – MODEL 757-200

Type:	Passenger transport
Accommodation:	187–228 passengers

A Rolls-Royce powered Air Europe 757-236 shows off the slim fuselage, distinctive flap track housings, and low point of nose. (*Boeing Photo P-56867*)

Power plant:	Rolls-Royce RB.211 or P & W2000 series 37,000–40,100 lb thrust
Fuel:	11,253 US gallons
Span:	124 ft 10 in
Length:	155 ft 3 in
Height:	44 ft 6 in
Wing area:	1,994 sq ft
Empty weight:	125,820/126,070 lb
Gross weight:	220,000 lb
Max speed:	Mach 0.86
Cruising speed:	Mach .80 at 38,200 ft
Range:	2,752/3,926 miles

By the end of September 1988 twenty-five 757-200 customers who had ordered 368 aeroplanes made the following choices of the four engine models available:
RB.211-535C: Air Europe*, British Airways, Eastern Air Lines*, LTJ, Monarch*; RB.211-535E4: Air Holland, American Airlines, America West, Ansett Worldwide, CAAC (Mainland China), El Al, International Lease Finance, LTU, Mexican Government, Republic Airlines, Royal Brunei, Royal Nepal; PW2037: Delta Air Lines, Northwest Airlines, Royal Air Maroc, Singapore Airlines, United Airlines; PW2040: Condor, United Parcel.

*Some aeroplanes were later fitted with -535E4 engines, others were delivered with this model.

MODEL 757-200C – A Combi cargo/passenger variant of the 757-200 has a cargo door forward of the wing and provision for two or three 88 × 108-in containers in the forward cabin. When containers are carried, passengers normally enter through the centre door. With two containers, passenger seating is for 14 first-class passengers and 174 tourist. In the all-passenger

The Boeing 757 followed earlier models in offering a convertible passenger-freight version as on this Royal Nepal 757-2F8CB. US registration N5573K was used for tests of 9N-ACB. (*Boeing Photo K-55653-17*)

configuration, the 757-200C can carry 16 first-class and 174 tourist passengers for a total of 190.

The empty weight of the 757-200C increased to 128,390 lb and the gross weight to 241,000 lb. Initial customer was Royal Nepal, which ordered one 757-2F8C Combi for delivery in September 1988, to follow its single 757-2FB delivered a year earlier.

For the specialized package-freight industry Boeing offered the windowless cargo-only 757-200PF model. This is the rollout ceremony for the first of twenty 757-24A PFs for initial customer United Parcel Service, July 1987. (*Boeing Photo P-59362*)

MODEL 757-200PF – This version was developed specifically for the package freight industry and is not convertible to passenger configuration. It has no cabin windows or doors and no provision for lavatories, galleys, and associated passenger accessories. A permanent rigid barrier with sliding door sets off an enlarged crew compartment with the standard two-pilot flight crew plus three permanent seats and two provisional seats for additional personnel. A new personnel access door farther forward than the normal passenger door is ahead of the port-side cargo door.

To make use of the maximum cabin space without having to use a special undersize container at the rear, where the cabin narrows, the fuselage formers at that point have been notched near the ceiling to accommodate the corners of a standard 88 × 125-in container. Fifteen such containers can be carried. Empty weight of the 757-200PF decreased to 114,500 lb while the gross weight increased to that of the 757-200 Combi.

The initial customer for the 757-200PF was United Parcel Service, which ordered twenty, with first delivery in October 1987.

MODEL 767

The Model 767 was designed as a medium- to long-range two-aisle transport with passenger capacity greater than the Model 707 but less than other two-aisle airliners smaller than the Boeing 747. The fuselage is 4 ft 1 in wider than that of other single-aisle, or standard fuselage, Boeing jetliners to permit seven and even eight-abreast seating.

The 767 uses a new-technology wing with 31·5 degrees of sweep and two wing-mounted engines. The trailing-edge flaps are simplified single type

The neat flight deck layout of the Model 767. Originally laid out for three crew it was later approved for two-crew operation. (*Boeing Photo P-55844*)

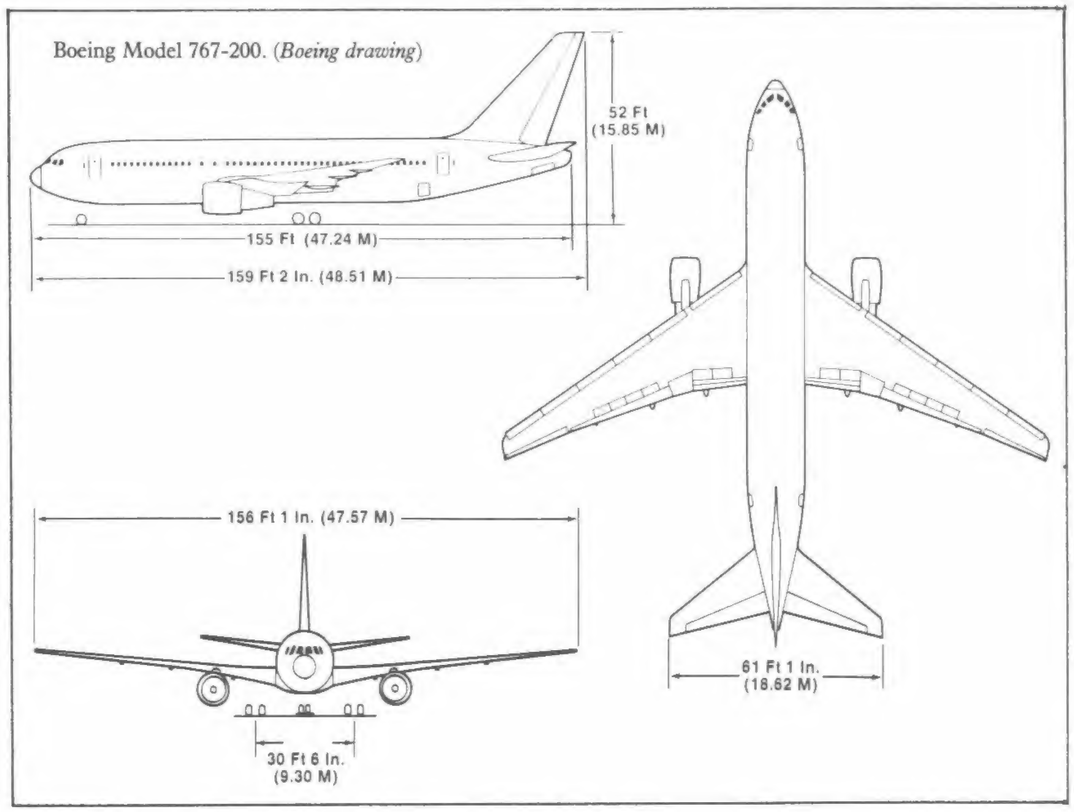
The rollout ceremony for the Boeing 767 prototype was an outdoor affair held at the Everett Plant on August 4, 1981. (*Boeing Photo P-55215*)

outboard of the engines and double type inboard. The initial engines offered were Pratt & Whitney JT9D-R4Ds of 48,000/50,000 lb thrust and General Electric CF6-80As with 57,900 lb of thrust. The flight deck was originally designed for a three-man flight crew, but approval was granted for a two-pilot crew after testing of the prototype in time for initial deliveries to be made in the new configuration. However, space is available for a third seat.

The Boeing-owned prototype, designated 767-200, rolled out of a newly-built extension to the Everett plant on August 4, 1981. First flight was on September 26, 1981, and Approved Type Certificate A1NM was awarded on July 30, 1982.

By September 30, 1988, 238 Model 767s had been delivered out of 316 ordered. By June 1988, the high-time aeroplane had 21,441 flying hours and the high-landing aeroplane had 12,419 landings. The initial price of a Model 767 was $41,000,000, which rose to a 1988 range of $51 to 60 million.

MODEL 767-200 – As with the Model 757, the Model 767 started with the 200 series. Seating varies between 18 first-class and 198 tourist passengers to 290 all-tourist, some 62 more than the 757-200. Seating is five-abreast on reclining sleeper seats in a Premium First Class in front of the cabin, with a single seat between the two aisles and two seats on each side between the aisles and the windows. Normal first class seating is six abreast with the aisles dividing the seats in a 2-2-2 arrangement. The tourist cabin normally has three seats between the aisles and two between the aisles and the windows in a 2-3-2 arrangement but can go to eight-abreast seating in a 2-4-2 layout.



Boeing Model 767-200. (*Boeing drawing*)

Four passenger doors are provided, two on opposite sides of each end of the cabin. If an additional overwing emergency exit is provided, tourist passenger capacity can be 290. Cargo and baggage are carried in the lower hold ahead of and aft of the wing.

Initial customer for the 767-200 was United Airlines, which ordered 30. First delivery to the airline was on August 19, 1982, and commercial service was inaugurated between Chicago and Denver on September 8, 1982.

TECHNICAL DATA - MODEL 767-200

Type:	Medium- to long-range transport
Accommodation:	216/290 passengers
Power plant:	P & W JT9D-R4D 48,000/50,000 lb thrust or General Electric CF6-80A2 57,900 lb thrust
Fuel:	16,700 US gal
Span:	156 ft 1 in
Length:	159 ft 2 in
Height:	52 ft 0 in
Wing area:	3,050 sq ft
Empty weight:	178,400 lb
Gross weight:	300,000 lb
Cruising speed:	Mach 0·80 at 39,200 ft
Service ceiling (one engine out):	23,200 ft
Range:	3,777 miles

A TWA 767-231, N601TW, with Pratt & Whitney JT9D engines. Compare nose contours with the Model 757. (*Boeing Photo P-56527*)

MODEL 767-200ER - The 767-200ER, for Extended Range, is dimensionally similar to the basic 767-200 and carries the same number of passengers with the same engines. The increased fuel capacity and higher gross weight permit the extended range, which exceeds that of the 747-100. The performance of the 767-200ER with one engine inoperative enabled the FAA to modify its restriction on the use of twin-engined transports on transoceanic routes, clearing the 767-200ER for transatlantic service.

Ethiopian Airlines, the initial customer, received its first 767-200ER on May 18, 1984, but El Al took the first delivery and was first into service on March 27. A 767-200ER delivered to Kuwait Airways on April 1, 1986, set a distance record for twin-engined airliners with a 7,892-mile nonstop delivery flight from Seattle to Kuwait.

TECHNICAL DATA - MODEL 767-200ER

As 767-200 except:

Fuel:	20,450 US gal

Ethiopian Airlines was the initial customer for the extended-range Model 767. This 767-260ER has the words Boeing 767-200ER appearing below the base of the fin. (*Boeing Photo P-57608*)

Empty weight:	179,700 lb
Gross weight:	345,000 lb*
Cruising speed:	Mach 0·80 at 36,900 ft
Service ceiling (one engine out):	23,400 ft
Range:	5,804 miles*

*A high-gross-weight version is approved for a take-off weight of 351,000 lb and a range of 6,080 miles.

The first 34 customers for the 767-200 and 767-300 chose between the four optional engines as follows:

Pratt & Whitney JT9D: Air Canada, Avianca, Braathens, Canadian, CAAC, China Air Lines, EgyptAir, El Al, Ethiopian, Japan, Kuwait, Lauda, Qantas, TWA, United; Pratt & Whitney PW4000: Air Zimbabwe, Avianca, Lauda, LTU, Martinair, SAS; General Electric CF6: Air Mauritius, Air New Zealand, All Nippon, American, Ansett, Britannia, Delta, Gulf Air, International Lease, Piedmont, TACA, Transbrasil, Varig; Rolls-Royce RB.211-524H: British Airways, Olympic Airways had not announced its choice of engines.

MODEL 767-300 – A 767-200 with the fuselage lengthened 10 ft 1 in ahead of the wing and 11 ft aft of the wing increased tourist seating by approximately 45. The undercarriage has been reinforced and heavier skins used in critical areas.

The first 767-300, powered with Pratt & Whitney JT9D-7R4D engines, flew on January 30, 1986, and was followed by a second test aeroplane using the General Electric CF6-80A-2 engine. Japan Air Lines was the initial customer, placing orders for an eventual total of ten with first delivery on September 25, 1986. Appropriately, the test aeroplanes were temporarily registered N767PW and N767GE, respectively. The Model 767-300 was added to the 767-200 Type Certificate on September 22, 1986.

The first 767-300, with Pratt & Whitney engines and Boeing markings. For publicity, it carried registration 767 PW before delivery to Japan Air Lines as 767-346 JA8236. (*Boeinng Photo*)

The first Extended Range 767-300 was the Boeing-owned 767-3T8 registered N767GE while testing General Electric engines. Later it was converted to 767-3P6ER for Polaris, which leased it to Gulf Air as A40-GF. (*Boeing Photo*)

TECHNICAL DATA – 767-300

As 767-200 except:	
Accommodation:	24 first class passengers, 237 tourist (261)
Length:	180 ft 3 in
Empty weight:	191,000 lb
Gross weight:	345,000/351,000 lb
Cruising speed:	Mach 0·80 at 36,500 ft
Service ceiling (one engine out):	21,000 ft
Range:	4,416 miles

MODEL 767-300ER – The 767-300ER is essentially the 767-300 with the fuel capacity increased to 20,450 US gallons, the empty weight increased to 195,200 lb, and the gross weight to 380,000 lb. Range is 7,400 miles with the P & W engine and 5,953 miles with the General Electric CF6-80C2 engine of 61,000 lb thrust. Customer engine choices are as for the Model 767-200.

MODEL 767/AOA – The Model 767 prototype has been modified for use in a five-year-plus US Army Airborne Optical Adjunct (AOA) project begun in August 1984. This is intended to determine if airborne optical sensors can provide early warning and tracking of enemy intercontinental ballistic missile (ICBM) warheads. Boeing is the prime contractor, with Hughes Aircraft Co of El Segundo, California, as sub-contractor for the infra-red sensor and the Space and Strategic Avionics Division of Honeywell Inc, of Clearwater, Florida, as sub-contractor for the on-board data processor.

The Boeing-owned 767 prototype, N767BA, after modification to 767AOA configuration for the US Army ballistic missile detection programme. (*Boeing Photo V2256*)

The sensor is housed in a cupola 86 ft long, 8 ft high, and 10 ft wide built atop the fuselage of the 767. Sliding doors open to expose the lenses of two separate sensors for comparative evaluation. To minimize atmospheric interference, the 767/AOA, with its 10/15-man crew, flies its 4–6-hour missions at 40,000 ft, an altitude well above normal Boeing 767 airliner routes.

Chapter 19

MISCELLANEOUS AEROPLANES – 1972–1988

In the 1970s and 1980s, Boeing produced a number of interesting experimental aeroplanes that do not fit conveniently into the foregoing chapters of this book. Some of these were all-Boeing designs and some were adaptations of existing non-Boeing designs to experimental missions through extensive redesign and the use of new Boeing-built major components. These were built or adapted by Boeing organizations separate from the Boeing Commercial Airplane Company (renamed Boeing Commercial Airplanes on February 18, 1988) that do not ordinarily build complete aeroplanes. As such, they do not carry on the established system of Boeing aeroplane designations and constructors' numbers.

YQM-94A COMPASS COPE – The name is taken from the US Air Force Aeronautical System Division Programme for the development of a long-range high-altitude reconnaissance/surveillance pilotless aircraft, or drone (also RPV for Remote Piloted Vehicle). Boeing Aerospace Company and Teledyne-Ryan were awarded contracts for two flying prototypes each.

Workers in the photograph give an idea of the size of the unique pilotless YQM-94A Compass Cope aircraft. (*Boeing Photo V-0422*)

The Boeing entry carried the designation YQM-94A and the Ryan YQM-98A.

The large size of the YQM-94A, dictated by its range and payload requirements, ruled out the air-launch procedure and the in-flight snatch or parachute recovery procedure used with smaller drones. Operation was to be as a conventional aeroplane, with rolling take-off and landing on a conventional runway.

The YQM-94A was designed from the start as a fully-remote-controlled aircraft and did not have to sacrifice fuselage volume to accommodate a test/check pilot.

The structure is primarily aluminium/glass fibre honeycomb. Use of the full span of the wing for fuel precluded inward retraction of the main undercarriage into the wing. The single-wheel units, adapted from a commercial Aero-Commander aeroplane, retract aft, with the mainwheels being enclosed in bullet-like fairings that project aft of the wing. The lower half of the forward fuselage is used for the guidance and control system and the upper half for payload.

Power was provided by a single General Electric J97 turbojet mounted above the fuselage and exhausting between the twin rudders. The first prototype rolled out of the Boeing Field hangar in which it was built on November 30, 1972. First flight was from Edwards Air Force Base, California, on July 28, 1973. It was destroyed in a crash on August 4. The second YQM-94A flew on November 2, 1974, and successfully completed its full flight-test programme and evaluation of the Compass Cope concept. The Air Force decided against production of Compass Cope aircraft. The surviving YQM-94A was stored temporarily but is now on display in the USAF Museum at Wright-Patterson AFB, Ohio.

View of the YQM-94A Compass Cope shows the main undercarriage units extended from wing-mounted pods. Note phototheodolite targets on engine nacelle and fuselage. (*Boeing Photo R-0691*)

The Augmentor Wing aircraft was adapted from a Canadian de Havilland DHC-5 to test a powered lift system on a new wing and power plant arrangement. (*Boeing Photo P-48158*)

TECHNICAL DATA - YQM-94A

Type:	High-altitude drone
Power plant:	General Electric J97-GE-100 5,270 lb thrust
Span:	90 ft 0 in
Length:	40 ft 0 in
Wing area:	491 sq ft
Empty weight:	5,500 lb
Gross weight:	14,400 lb
Cruising speed:	Mach 0·5–0·6 at 50,000–70,000 ft
Endurance:	30 hours
USAF serial numbers:	71-1839, 1840

NASA/CANADIAN GOVERNMENT AUGMENTOR WING – This was a joint programme of NASA and the Canadian Department of Industry, Trade, and Commerce (DITC) to study the feasibility of a powered-lift short take-off and landing (STOL) transport aeroplane. The powered-lift concept, in which jet exhaust is blown over deflected trailing-edge flaps to produce additional lift, is also known, at least in its application to this particular aeroplane, as an augmented wing.

The aeroplane selected for modification was the US Army's C-8A version of the Canadian de Havilland DHC-5 Buffalo propeller-turbine transport. The T-tail, high wing, and proven STOL capabilities of the C-8A suited it for the conversion and for comparison of powered lift to conventional lift in otherwise similar aircraft. Boeing was selected to undertake the

This view shows the fully-deflected inboard flaps of the Boeing/de Havilland Augmentor wing aircraft. NASA Fleet Number is 716, matched to civil registration N716NA. (*Boeing Photo P-48161*)

modification, which was accomplished by the Boeing Aerospace Company in the Boeing Developmental Centre on Boeing Field. This consisted of rebuilding the wing to accommodate the augmentor flaps, installation of a boundary-layer control system to retain aileron control at low airspeeds, installation of full-span leading-edge slats, and installation of the propulsion system. Modified engine nacelles containing Rolls-Royce Spey turbojets were provided by de Havilland of Canada. These engines were modified to exhaust fan air through two outlet ducts at the top of the engine for blowing over the flaps, plus vectorable nozzles on each side of the engine near the bottom to provide from 18 to 116 degrees of vectored downward jet thrust. Because of the lower position of the modified engines in the nacelle, the undercarriage could not be retracted so was locked in the down position.

The first YC-14, with loading ramp partly open and outer trailing-edge flaps deflected. (*Photo by Jay Miller*)

The augmentor wing aeroplane was rolled out on February 5, 1972, and the first flight was made on May 1. Initial flight testing and delivery by air to NASA was accomplished by Boeing flight crews. The augmentor wing aircraft proved the concept to be workable, but no civil or military production has been undertaken.

TECHNICAL DATA - AUGMENTOR WING*

Type:	Powered-lift Research Aircraft
Accommodation:	Two flight crew and test personnel
Power plant:	Rolls-Royce Spey 801, 9,000 lb thrust
Span:	78 ft 9 in (reduced from 96 ft)
Length:	93 ft 4 in (excluding probe)
Wing area:	865 sq ft (decreased by 80 sq ft)
Empty weight:	32,000 lb (increased by 9,400 lb)
Gross weight:	45,000 lb (increased by 4,000 lb)
Stalling speed:	47·5 mph
Registration:	N716NA

*Differences in wing span and area, as well as aeroplane weight differences, make direct comparison of Augmentor Wing and C-8A performance difficult.

YC-14 STOL TRANSPORT – In 1972 the USAF sought proposals from the industry for potential replacements for the venerable Lockheed C-130 propeller-turbine transport series, the eventual winner to be selected as the result of a fly-off competition. Boeing Aerospace and McDonnell Douglas were the two finalists and each received contracts for the production of two prototypes, the Boeing YC-14 and the McDonnell Douglas YC-15. Because of the highly experimental nature of these designs, and the entirely new lift systems involved, it is hard to understand why only a Service Test Y-designation was assigned instead of a more logical X-for-Experimental.

Boeing adopted a relatively small critical wing mounted at the top of the fuselage and supporting two 55,000 lb thrust General Electric CF6-50D

The first of two Boeing YC-14s under test at Edwards Air Force Base in May 1976. (*Photo by Jay Miller*)

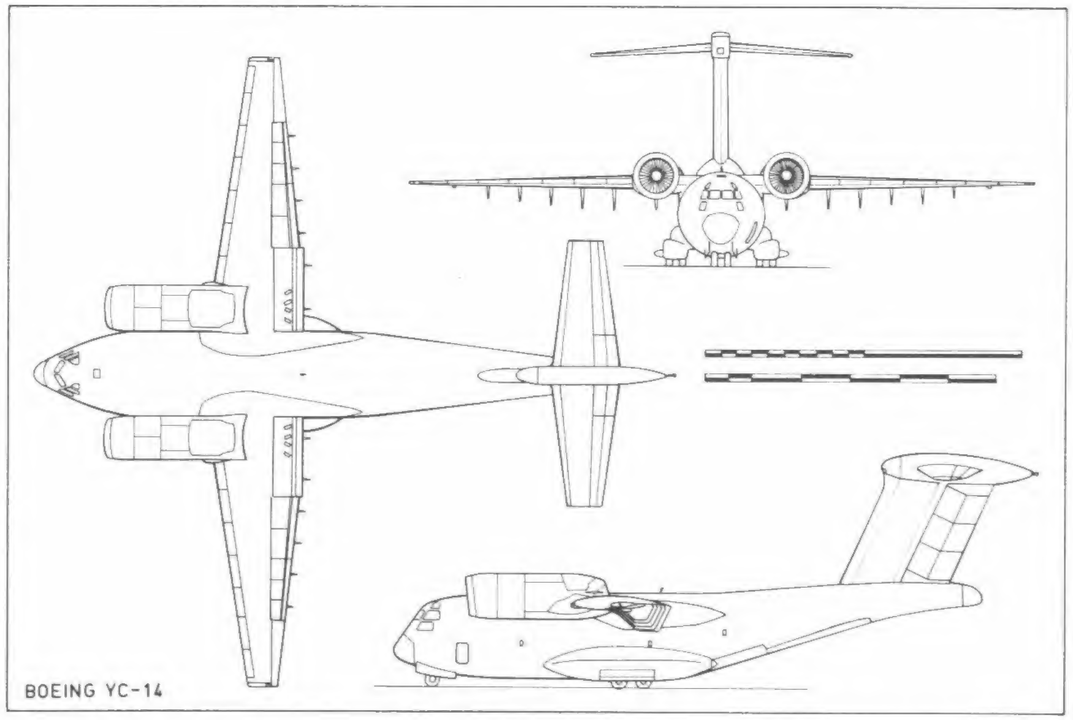
Boeing YC-14 with undercarriage lowered and leading-edge flaps extended. Note the prominent hinge supports for trailing-edge flaps. (*Boeing photo*)

turbofans. These were placed ahead of the wing so that their efflux would flow over the inboard portion of the wing and special trailing-edge flaps in a form of powered lift known as Upper Surface Blowing (USB). When the flaps are lowered, the high-velocity jet stream follows the curvature of the lowered flaps through the Coanda Effect to generate aerodynamic lift, after which the downward-deflected jet stream contributes to dynamic lift.

Superior STOL performance and low-speed manoeuvrability resulted from the design of the critical wing and blown leading-edge slats. Cargo and wheeled vehicles can be loaded into the wide fuselage via a tail ramp.

The two YC-14s in flight. The unpainted aeroplane was the first example. (*Boeing Photo V-1580*)

Visibility from the flight deck of the YC-14 is much better than that from a commercial jetliner. (*Boeing Photo FA-104235*)



During construction of the aeroplanes the US Congress reduced the appropriation of funds under which they were being built, so completion was delayed. The YC-14s were built in the Boeing Developmental Centre on Boeing Field and the first one flew on August 9, 1976. The first was in natural metal finish and the second was camouflaged.

The YC-14s were flown against the YC-15s, but the competition was never resolved; the planned C-130 replacement programme was cancelled and there was no C-14 or C-15 production. Boeing leased both YC-14s back from the Air Force for a while, flying them under civil registration. Following return to the Air Force, one was put on display at the Pima Air Museum in Tucson, Arizona, and is there at this writing (1988).

While no further work has been done in the United States with USB other than the Boeing QRSA (*which see*), near-duplicates of the YC-14 have been produced in the USSR as the Antonov An-72 and the An-74, both somewhat smaller than the YC-14, and in Japan as the National Aerospace Laboratory ASQUA research aircraft. Like the YC-14, the Antonovs have two engines while the ASQUA has four.

TECHNICAL DATA - YC-14

Type:	STOL transport
Accommodation:	150 troops or 27,000 lb cargo
Power plant:	General Electric CF6-50D, 51,000 lb thrust
Span:	129 ft 0 in

Unloading a tank from the second YC-14. Note the open position of the thrust reversers on the engines. (*Boeing Photo R-1248*)

Length:	131 ft 8 in
Height:	48 ft 4 in
Wing area:	1,762 sq ft
Empty weight:	117,500 lb
Gross weight:	251,000 lb
Gross weight (STOL):	170,000 lb
Take-off run:	1,000 ft
Landing run:	1,180 ft
Max speed (STOL):	504 mph at altitude
Max speed (STOL):	403 mph at sea level
Cruising speed (STOL):	449 mph at altitude
Service ceiling (STOL):	45,000 ft
Climb (STOL):	6,350 ft/min
Range (STOL):	460 miles (operating radius)
Range (STOL):	3,190 miles (ferry)
USAF serial numbers:	72-1873, 1874
Civil registrations:	N8730B, 8740

QUIET SHORT-HAUL RESEARCH AIRCRAFT (QSRA) - To develop technology for quiet short-range STOL transports of the future and to explore their operational capabilities in close-in metropolitan air terminal environments, NASA awarded Boeing Aerospace a $21,000,000 contract to convert another de Havilland of Canada C-8A Buffalo into a specialized research aeroplane.

Boeing converted the C-8A at the Development Centre on Boeing Field. An entirely new wing was built, with boundary layer control from jet engines and bleed air ducted to the wing leading edge and the ailerons. The ailerons operated differentially for roll control and could be lowered together to act as supplementary trailing-edge flaps. The main flaps were Coanda type in the area behind the engines to provide lift from upper-surface blowing as on the YC-14. New tail surfaces were also built that greatly resembled the originals.

The Boeing/NASA QSRA was another conversion of a DHC-5 to test a new wing-power plant combination for research on quiet short-range transports. (*Boeing Photo P-52600*)

Power was supplied by four AVCO Lycoming YF-102 turbofans, each with 7,500 lb thrust, installed in Boeing-designed nacelles. In addition to providing lift through upper surface blowing, the above-wing location of the engines greatly reduces the noise impact of the engines on the ground, a desirable feature for aircraft expected to operate near metropolitan areas.

Following its first flight on July 6, 1978, the QSRA was able to demonstrate exceptional low-speed flight down to 58 mph and steep and short landing approaches, desirable design goals. Short take-offs and unusually steep climbouts were also demonstrated.

Again, because of dimensional and power differences, plus the purely experimental nature of the QSRA, direct performance comparison with the C-8A is meaningless.

TECHNICAL DATA - QSRA

Type:	Quiet STOL Research Aircraft
Accommodation:	Two pilots
Power plants:	AVCO Lycoming YF-102, 75,000 lb thrust
Span:	73 ft 6 in
Length:	93 ft 3 in
Wing area:	600 sq ft
Empty weight:	36,800 lb
Gross weight:	60,000 lb (overload)
Cruising speed:	184 mph
Registration:	N715NA

NOTE: One major Boeing project that was never completed, and should therefore be included in Appendix I, is presented in this chapter because of the widespread national effort involved in its creation and the controversial status that it attained.

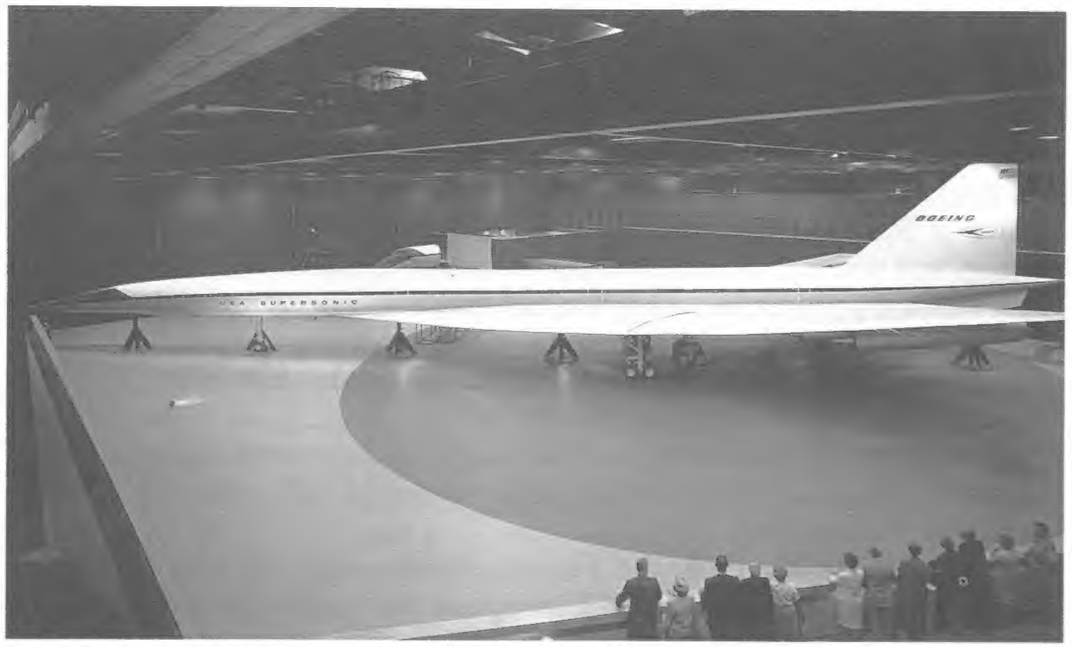
This view of the QSRA shows stains from direct jet engine efflux on the inner trailing-edge flaps. Outer flaps receive bleed air from the jet engines ducted through the wing. (*Boeing Photo K-32346*)

SUPERSONIC TRANSPORT - BOEING MODEL 733, 2707 - The subject of the Supersonic Transport (SST) has been highly controversial since its conception. Other than the practical considerations of cost and the need for such an aeroplane, there has been vehement objection from environmentalists who cite the expected damage from the sonic boom and the effect of high-altitude SST vapour trails on the earth's ozone layer. Such controversy became world-wide, and in the United States, never has a civil aeroplane programme involved such high levels of officialdom.

The sonic boom problem was resolved, with subsequent reduction of SST utility, by limiting supersonic operation to over-ocean stages of flight only. The atmospheric question is still not fully resolved in spite of the operation of thousands of supersonic military aeroplanes and high-flying long-range subsonic transports and the one in-service SST design, the Anglo-French Concorde.

Boeing research into supersonic transport design began in 1952. However, it soon became apparent that the cost of designing and producing a prototype would be prohibitive for a single company working alone. With the sum of $16,000,000 in company funds already committed to development of the first American jet transport, the supersonic transport was confined to study status for several years. It achieved project status in 1958 and then grew to the point where a Supersonic Transport Division was formed in 1966. The National Aeronautics and Space Administration (NASA) was also conducting SST studies and Boeing as well as other US manufacturers worked closely with it on the common problems.

In 1963 the government, recognizing that the development costs of an SST were beyond the capability of any single manufacturer, announced a



Full-scale mock-up of the Boeing 2707-200 Supersonic Transport with wings extended to the take-off and landing position with 20 degrees of sweep. Man on floor gives scale. Canard control surfaces were subsequently added (see drawing). (*Boeing Photo P-40448*)

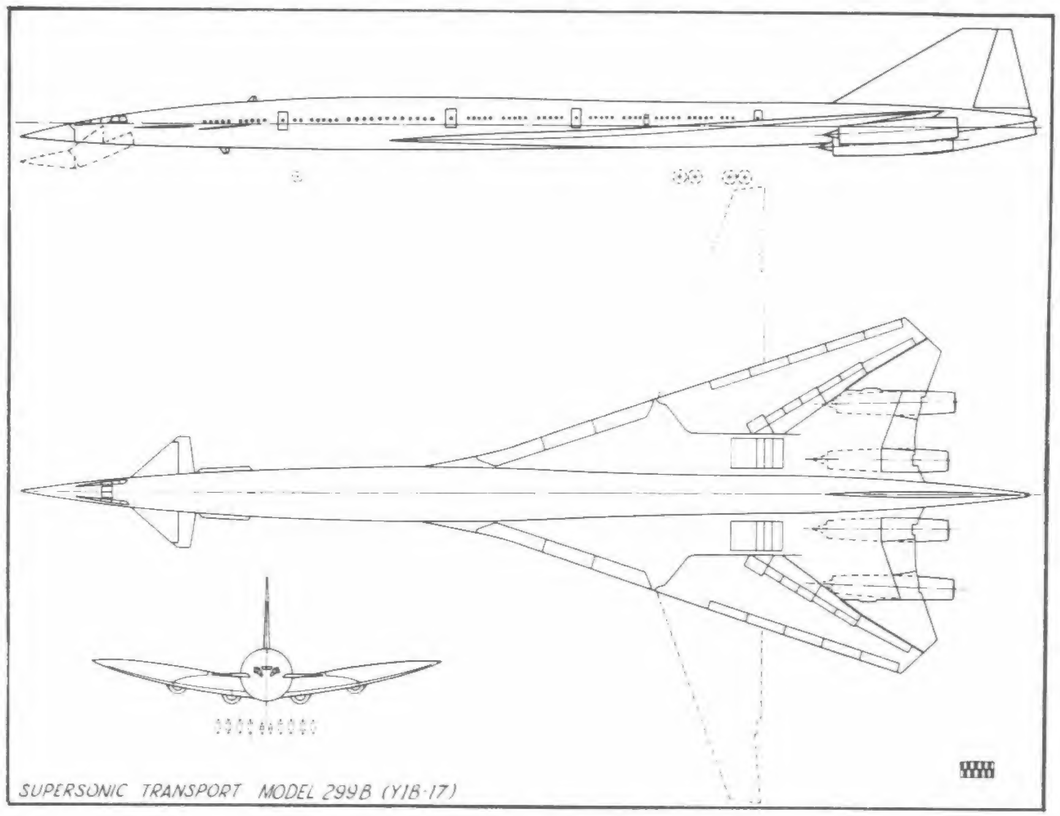
design competition for an American SST, with one or more prototypes of the winning design to be financed largely with government funds. Since no suitable power plants were in existence at the time the SST competition was announced, a separate competition was set up for the development of augmented turbojets in the 35,000–40,000 lb thrust range.

For the first phase of the SST competition, which closed in January 1964, Boeing entered a 150-227 passenger design designated Model 733 with a design cruising speed of Mach 2·7, or approximately 1,800 mph. Aerodynamic heating problems at this speed dictated the use of titanium alloy for the structure instead of aluminium. The 733 featured a relatively conventional fuselage and tail with four individually-podded engines under the centre section of the low wing. The distinctive characteristic of the 733 design was the use of a variable-sweep wing. This was a logical extension of the use of variable geometry to increase the range of aircraft performance as exemplified by the sequential adoption of retractable undercarriage, flaps, controllable-pitch propellers, leading-edge slats, etc. With the wing in the fully-swept position of 74 degrees, the high speed performance was enhanced. By sweeping the wing forward to the 20-degree position the Model 733 was expected to have take-off and landing characteristics comparable to the Intercontinental jetliners then in service.

Before the second phase of the competition was to be completed in September 1966, Boeing seriously reconsidered the economics of the SST as well as the power plant and aerodynamic problems, and came up with an enlarged and revised design tentatively designated B-2707. The original 733 designation was dropped completely. While the variable-sweep wing was retained, the major changes were increase in size and capacity to over 300 passengers and relocation of the engines to a position under a greatly enlarged horizontal tail surface. With the new arrangement, the fully-swept wing mates with the horizontal tail to form a single delta-wing aircraft configuration. When extended, the wing has the normal subsonic wing's full complement of leading- and trailing-edge flaps. One other geometric change was made at this time – the nose was articulated ahead of the pilot's station so that it could be drooped for improved pilot visibility during landing, taxiing, and take-off. A second joint was added ahead of the first so that the most forward portion, including the radome, could bend upward relative to the rest of the nose, thereby remaining parallel to the ground and increasing ground clearance. This feature became necessary not because of an unusually high angle of attack for take-off and landing, as in the case of a delta-wing aircraft, but because of the length and contours characteristic of the supersonic nose, which has no stepped windshield as on the subsonic transports and bombers.

On December 31, 1966, the Federal Aviation Agency announced that Boeing was the winner of the SST aeroplane competition and that General Electric had won the competition for the engines to power it. Approval for the construction of two prototypes was granted by President Richard Nixon

on 23 September, 1969, with first flight scheduled for early 1973; production was to begin in 1973–74 and certification to be obtained in 1978. In the meantime, Boeing abandoned the variable-sweep wing and revised the 2707-200 design to the 2707-300 with a fixed delta wing supplemented by conventional horizontal tail surfaces. Wing structure was changed from the original machined skins to sandwich skins.



TECHNICAL DATA - BOEING SUPERSONIC TRANSPORT MODEL 2707-200

Type:	Supersonic transport
Accommodation:	250–350 passengers
Power plant:	General Electric GE4/J5
Span:	(20-degree sweep) 174 ft 2 in (72-degree sweep) 105 ft 9 in
Length:	318 ft
Height:	46 ft
Wing area:	9,000 sq ft
Gross weight:	675,000 lb
Cruising speed:	Mach 2·7 (1,800 mph)
Cruising altitude:	64,000 ft
Range:	Over 4,000 miles

By 1970, twenty-six airlines had reserved production line positions for 122 SSTs. However, before construction of the 2707-300 actually started

The only officially released photograph of the Boeing twin-engined unmanned aircraft first flown in October 1988. (*Boeing Photo*)

the US Congress terminated the project on March 24, 1971. The elaborate 2707-200 mock-up was sold to a promoter who placed it in a Florida amusement park where it remains.

Boeing interest in SST development has continued, and at this writing (late 1988) the company holds a NASA contract for studies of a Mach 2·5–3·0 SST.

CONDOR HALE DRONE – On October 9, 1988, Boeing Advanced Systems began flight testing a large twin-engine robotic aircraft nicknamed 'Condor'. Designed for anticipated civil and military requirements, the all-bonded composite structure airframe is designated HALE, for High-altitude Long Endurance, and has been partially funded by the Defense Advanced Research Projects Agency (DARPA).

The Condor is not a traditional radio-controlled drone aircraft: it is robotic, meaning that it can take off and perform an entire pre-programmed mission from data stored in its on-board computers. These commands can be altered in flight by ground controllers.

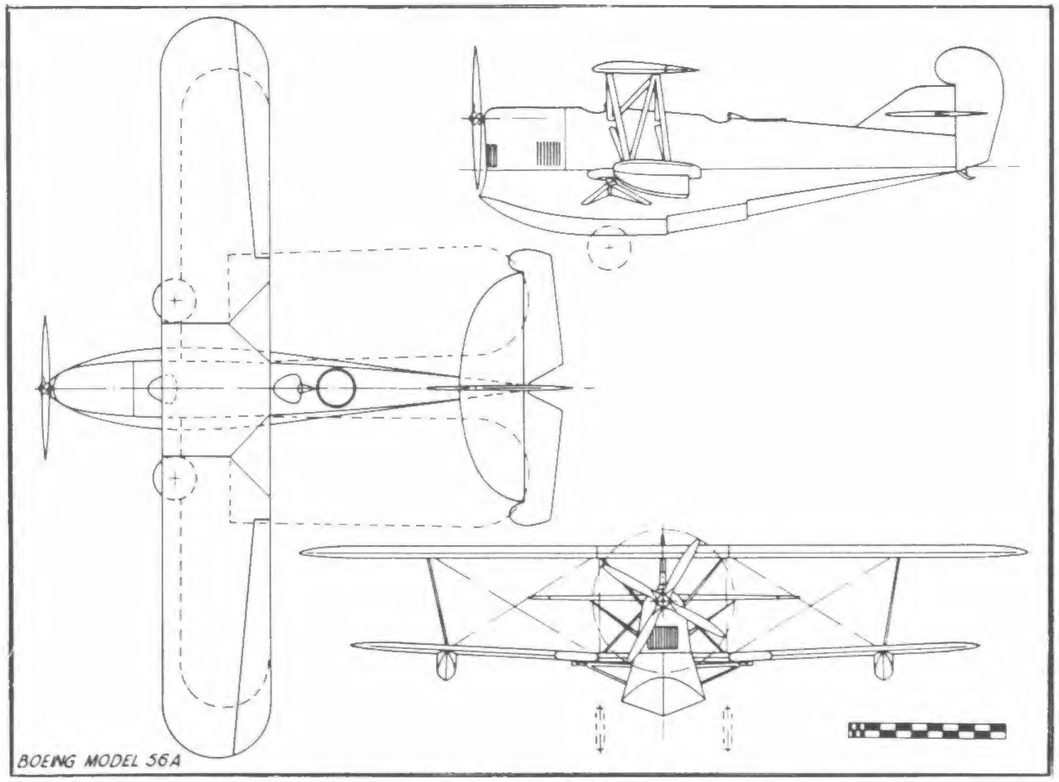
Performance of the Condor set two new American altitude records for piston-powered aircraft in its class in 1989. These were 66,980 ft altitude, surpassing by 11,000 ft a world record that had stood since 1938, and a new record for altitude in continuous flight, though the new altitude was not specified.

The Condor was still highly classified when the above information was released by Boeing in June, 1989. Wing span is given as 'some 200 feet', and powerplants are reported to be two six-cylinder geared-down and turbo-charged liquid-cooled engines developing 175 hp each. Endurance is said to be measured in days rather than hours.

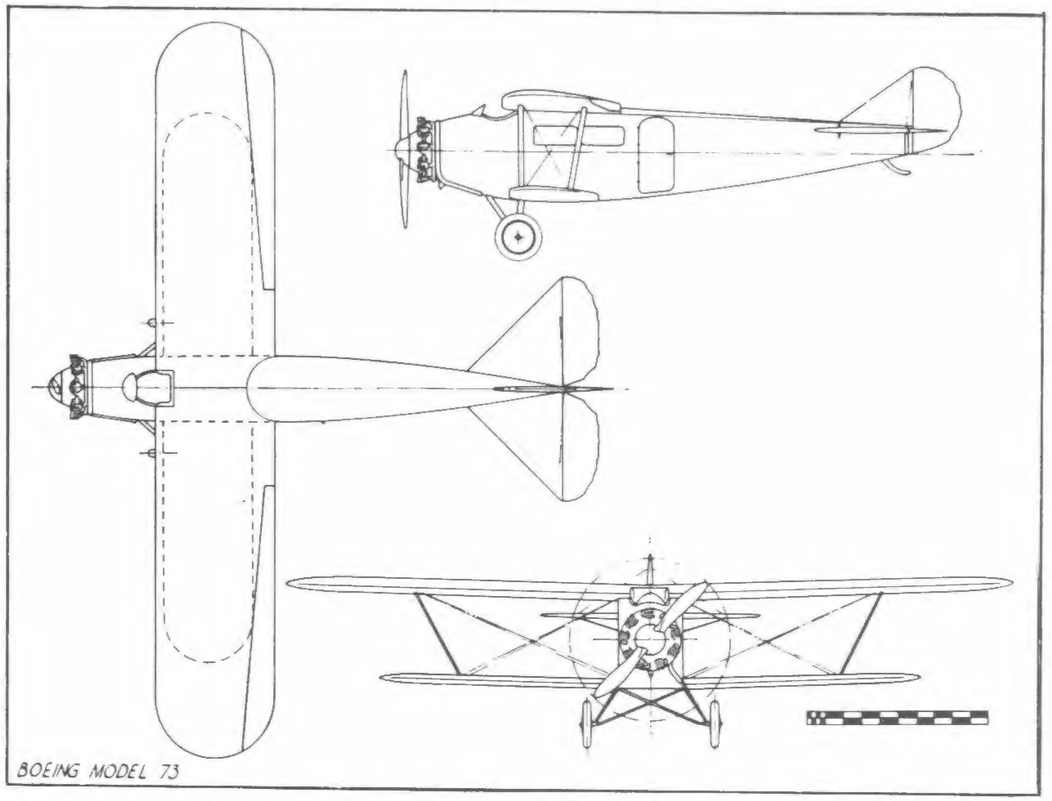
Appendix I
BOEING PROJECT DRAWINGS

The following three-view drawings, prepared by L E Bradford from Boeing project drawings, illustrate representative aircraft designs that in spite of having reached advanced study stages were not built. Some were initiated by Boeing to supply an anticipated market while others were developed as a result of specifications issued by the armed services for specific aircraft types. Some of the military designs received government support to the extent of having military designations assigned before being cancelled for various reasons.

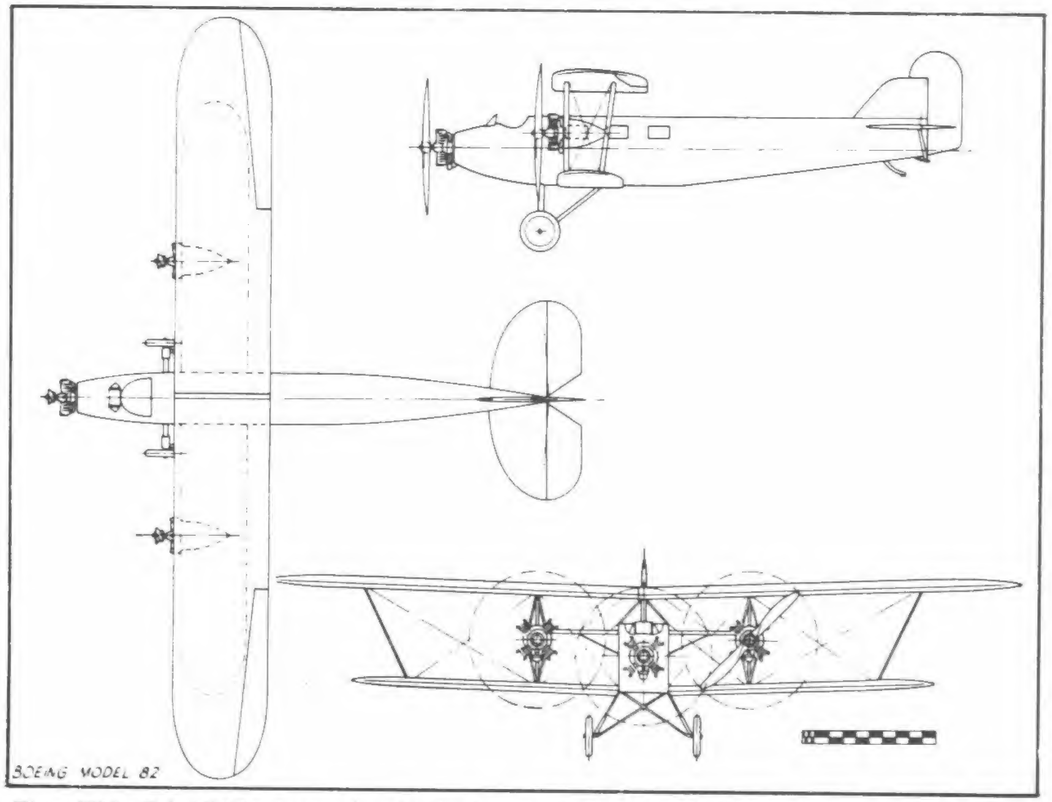
Prior to World War II, most design studies were assigned a separate Boeing model number even in cases of relatively minor variants of a single basic design (see Chapter 5, Famous Fighter Family). In a few cases, basic design variants were identified by suffix letters, as Model 40A, 40B, 40C, etc. Since the start of WW-II, a great number of design studies have been conducted under a single model number, with 'dash numbers' used to identify the different configurations. An outstanding example is the Model 367-64 illustrated in this appendix. The original Boeing Model 367 was produced as the long-lived USAF C-97 Stratofreighter. Advanced configuration studies using this Boeing number resulted in the Model 367-80 jet transport prototype, which was put in production as the Model 707.



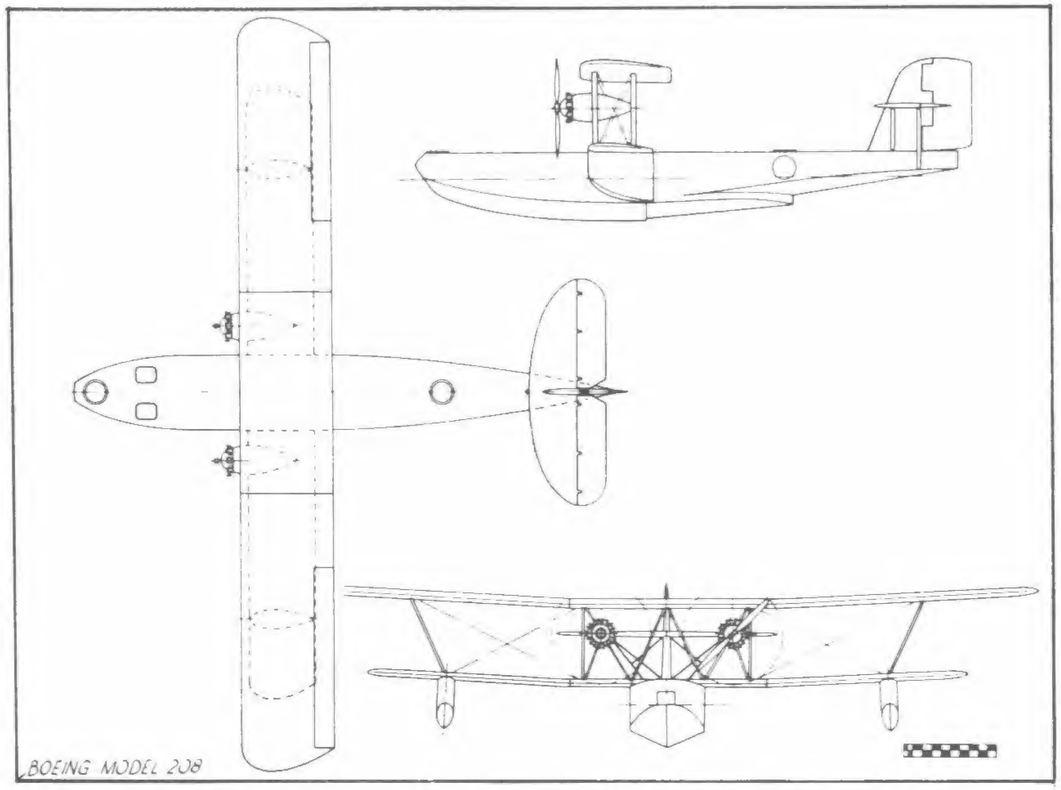
Unique fleet spotter amphibian designed in 1925 to use inverted Packard 1A-1500 engine of 500 hp. Span 46 ft 6 in, length 33 ft 10 in, gross weight 5,050 lb.



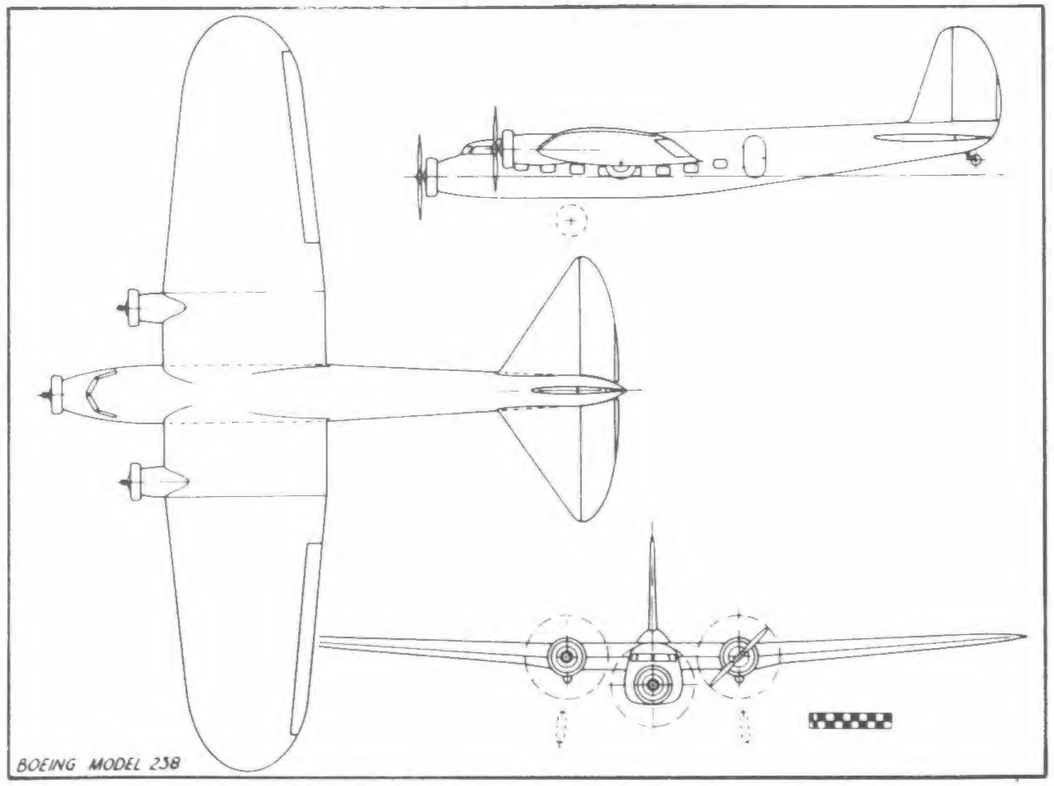
Five-seat commercial biplane, 1926. Engine 200 hp Wright J-4. Span 40 ft, length 31 ft 2 in, gross weight 3,498 lb



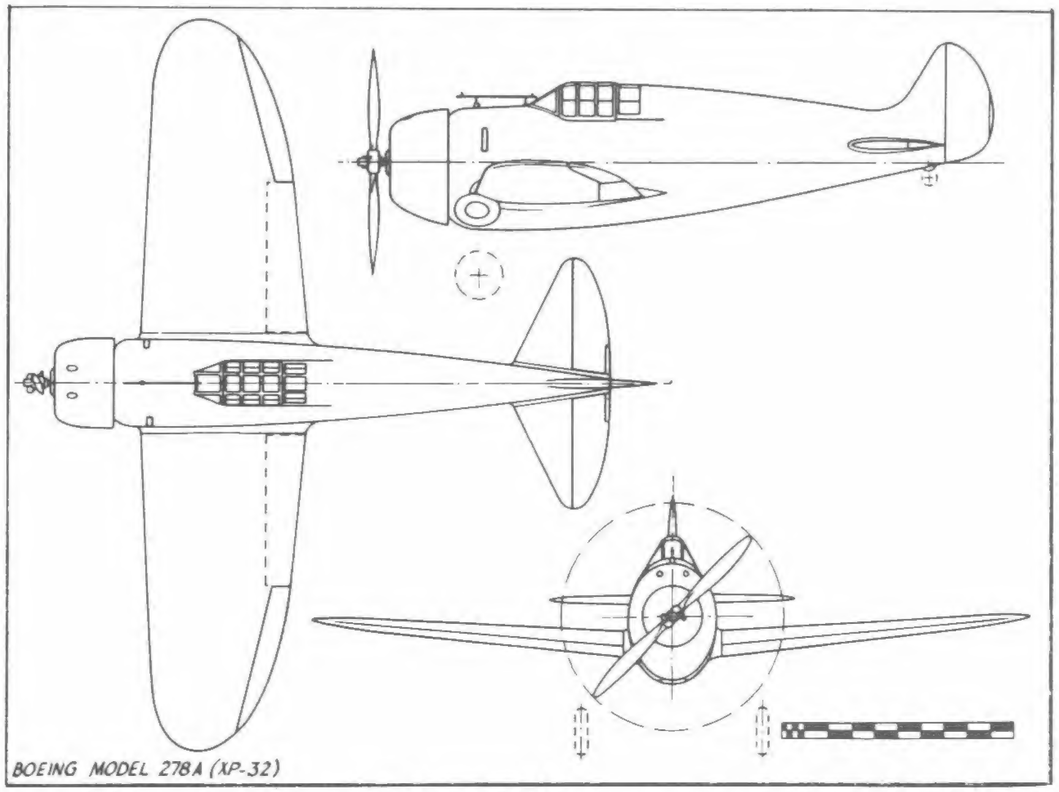
Three 120 hp Fairchild Caminez engines fitted to a 1927 six-passenger design to bring multimotor reliability to the small transport. Span 56 ft, length 41 ft 4 in, gross weight 6,000 lb.



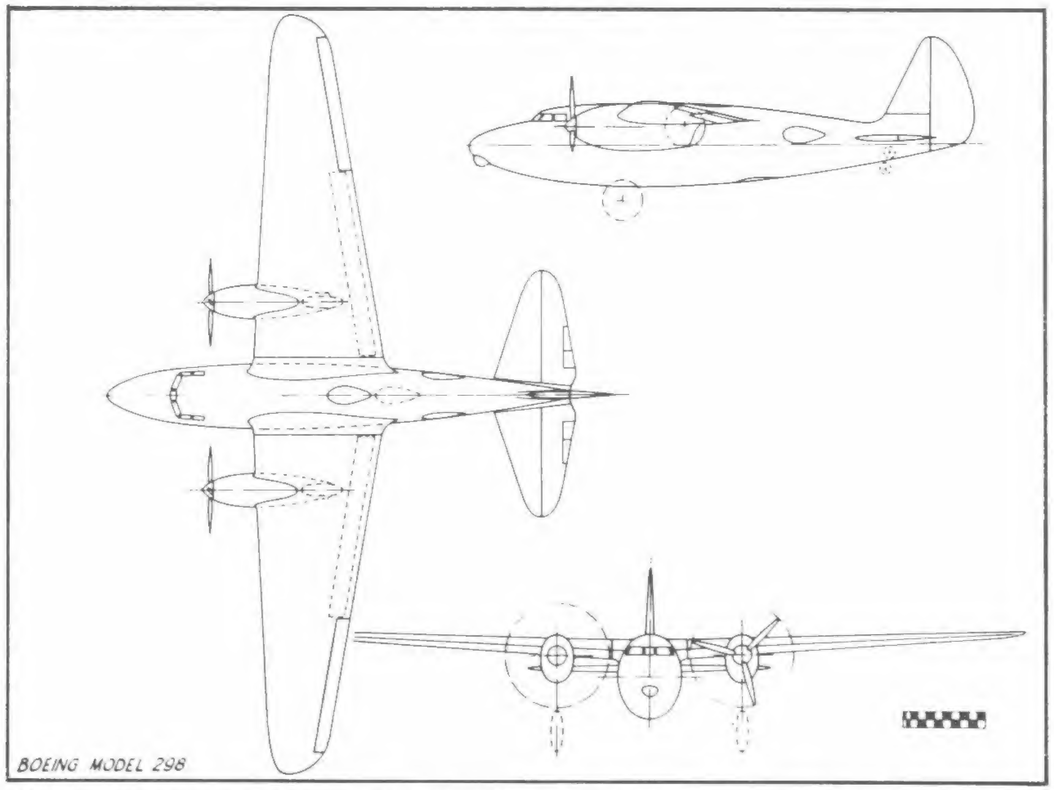
Five-seat Navy flying-boat designed in 1929 to use wings of the Model 80 trimotor transport. Two 525 hp Pratt & Whitney Hornet engines. Span 80 ft, length 59 ft 10 in, gross weight 15,483 lb.



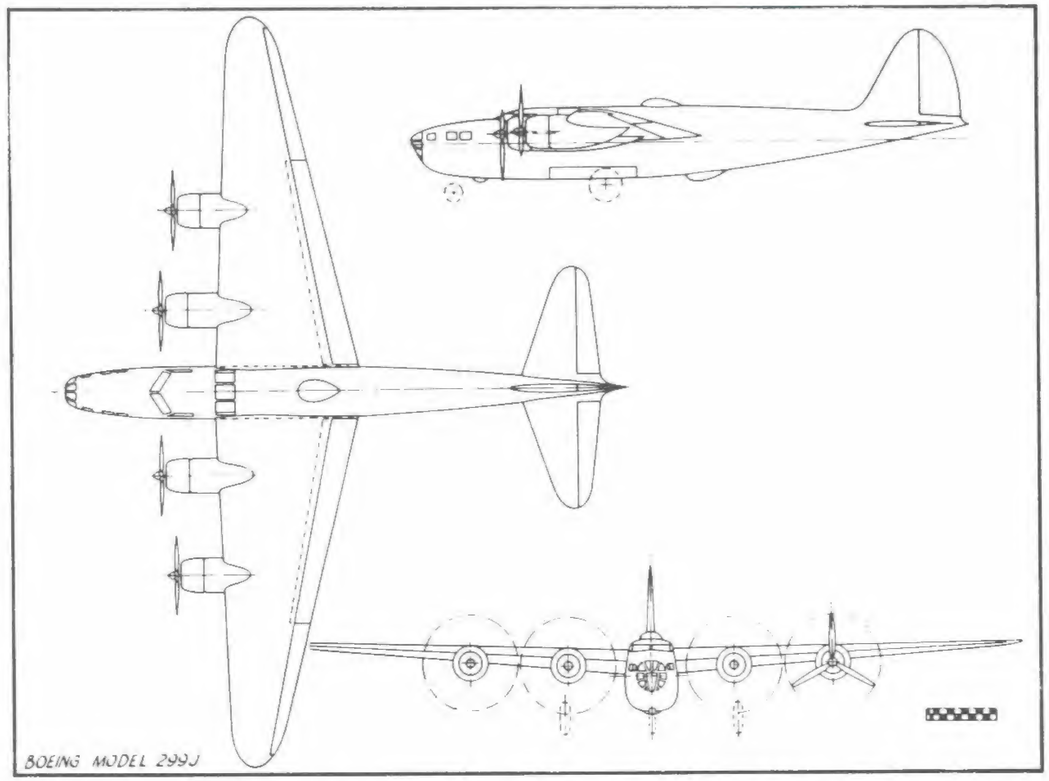
All-metal 12-passenger transport design of 1931 that was abandoned in favour of the more advanced Model 247. Three 550 hp Pratt & Whitney Hornet engines. Span 90 ft, length 70 ft 7½ in, gross weight 20,300 lb.



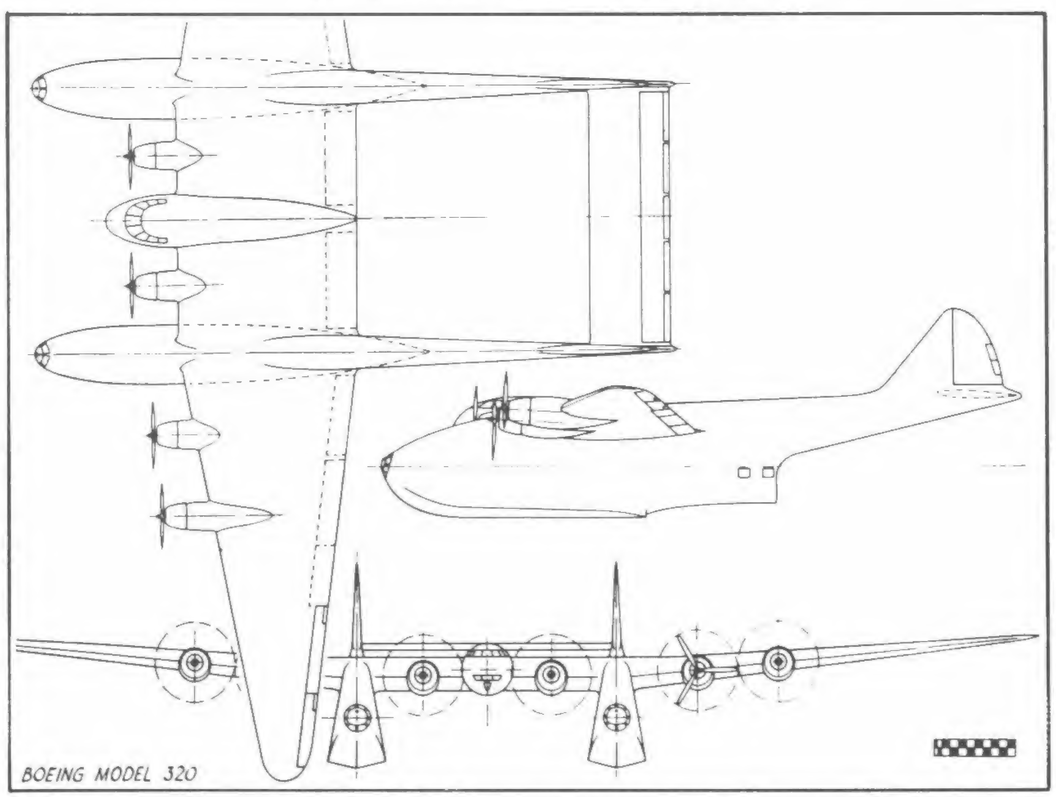
Advanced fighter of 1934 received Air Corps designation of XP-32. The landing-gear design later appeared on the Brewster F2A-1 Navy fighter of 1938. Engine 750 hp Pratt & Whitney Twin Wasp Jr. Span 31 ft, length 27 ft 5 in, gross weight 3,895 lb.



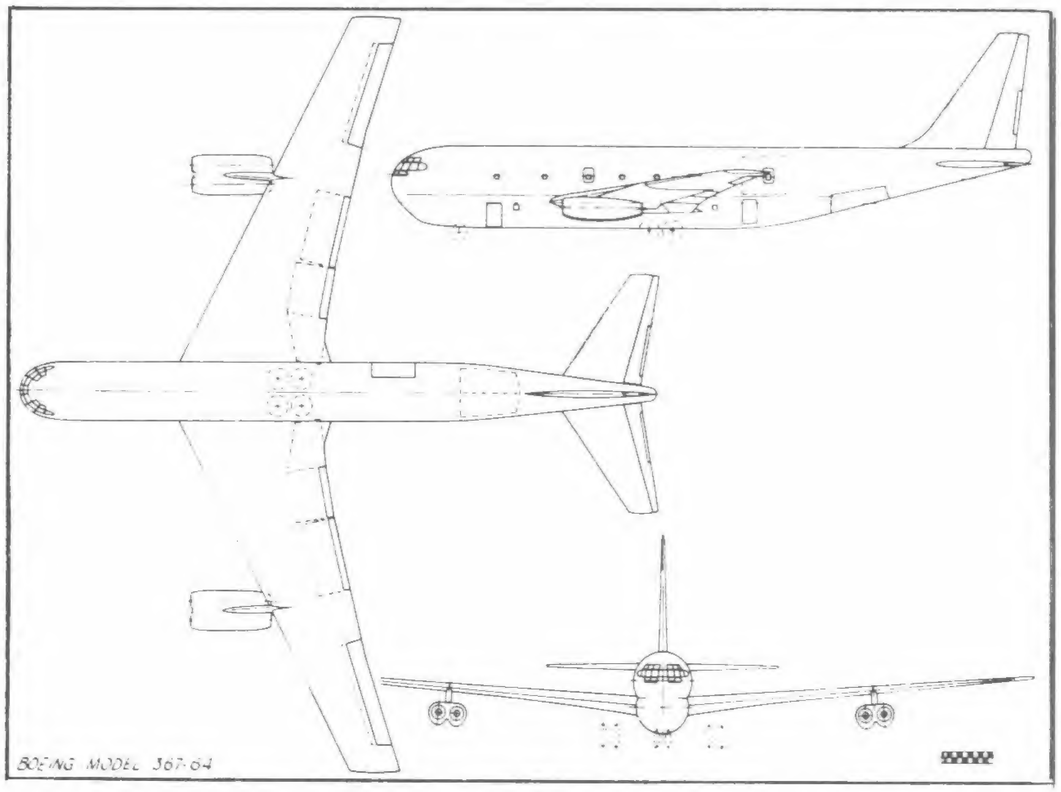
Experimental twin-engine bomber of 1934 with 1,600 hp Allison V-1710-3 engines. Span 94 ft, length 63 ft 4 in, gross weight 25,667 lb.



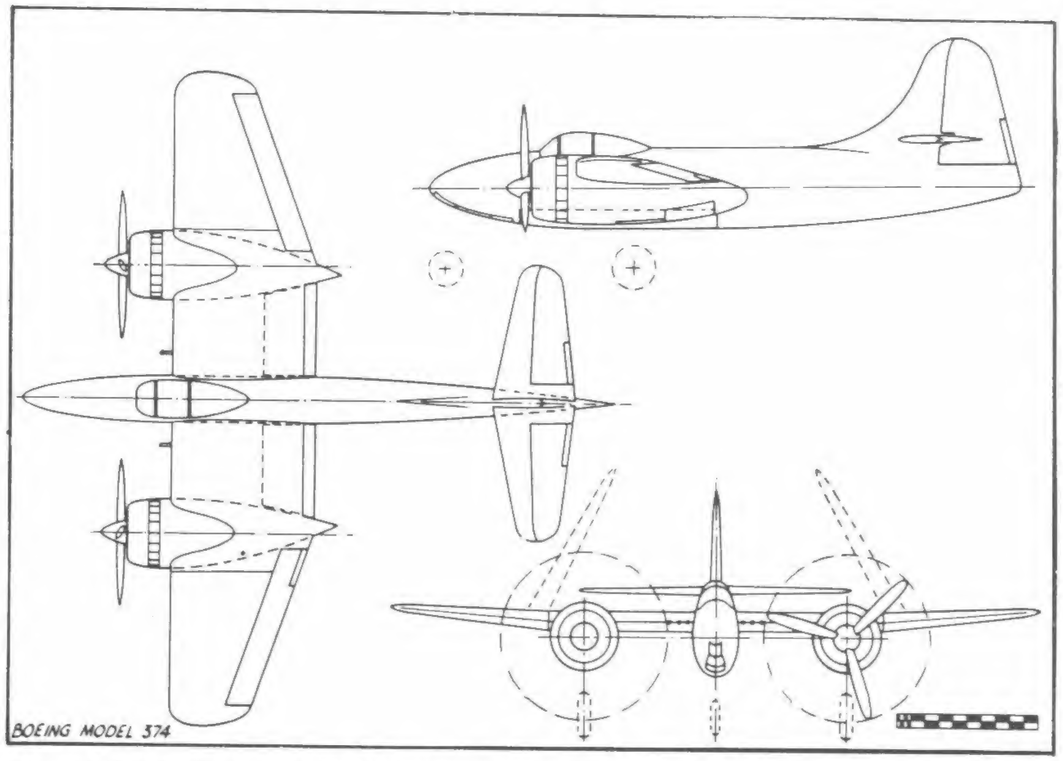
A study to evaluate the existing B-17 (Boeing Model 299) redesigned as a high-wing bomber with tricycle landing gear in the style of the then new Consolidated B-24. Four 1,400 hp Pratt & Whitney R-2180 engines. Span 104 ft, length 79 ft, gross weight 41,819 lb.



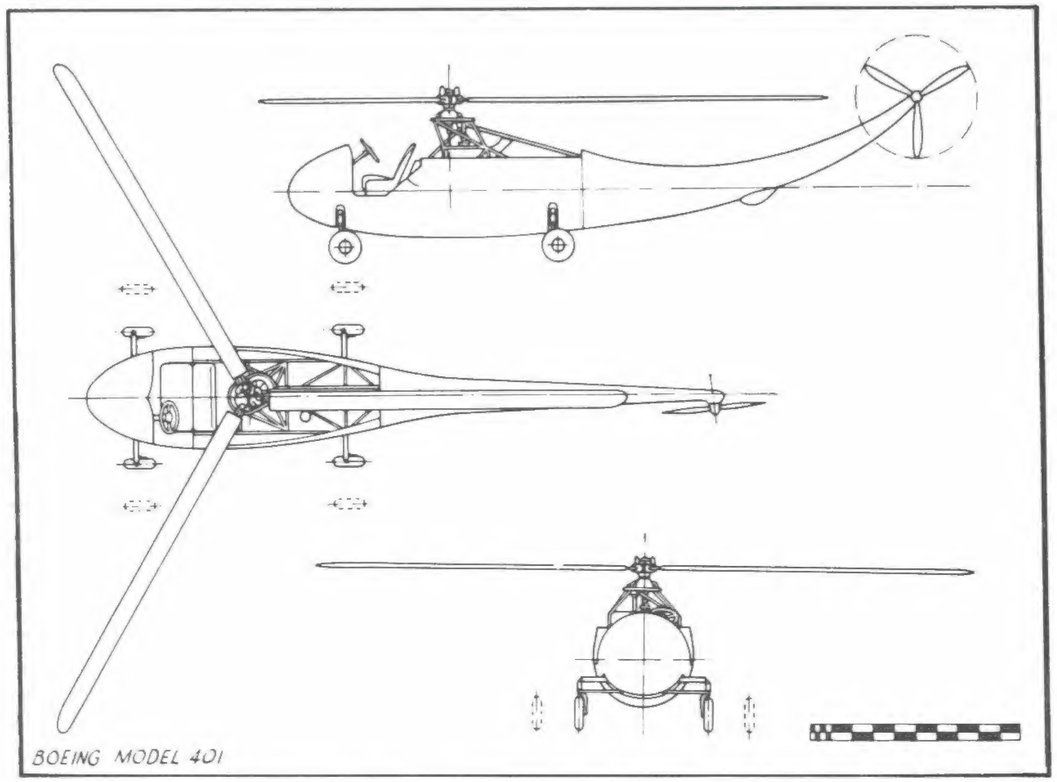
A 1938 study for an 8-seat twin-hull Navy patrol aircraft. Six 1,200 hp Wright GR-2600 Twin Cyclone engines. Span 200 ft, length 116 ft, gross weight 134,000 lb.



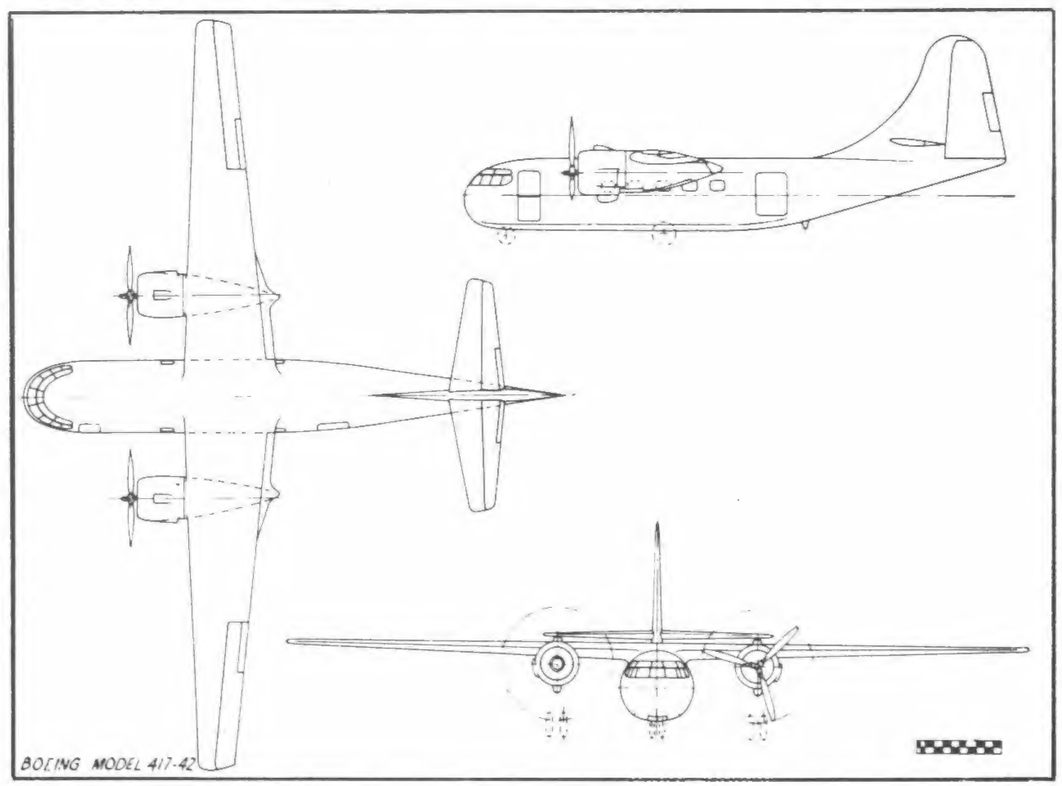
One of the many configurations studied during the transition of the Model 367 (USAF C-97) from a straight-wing piston-powered model to a swept-wing jet. Four Pratt & Whitney J-57P-1 engines in double pods in the style of the B-47/B-52. Span 140 ft, length 127 ft 6 in, gross weight 190,000 lb.



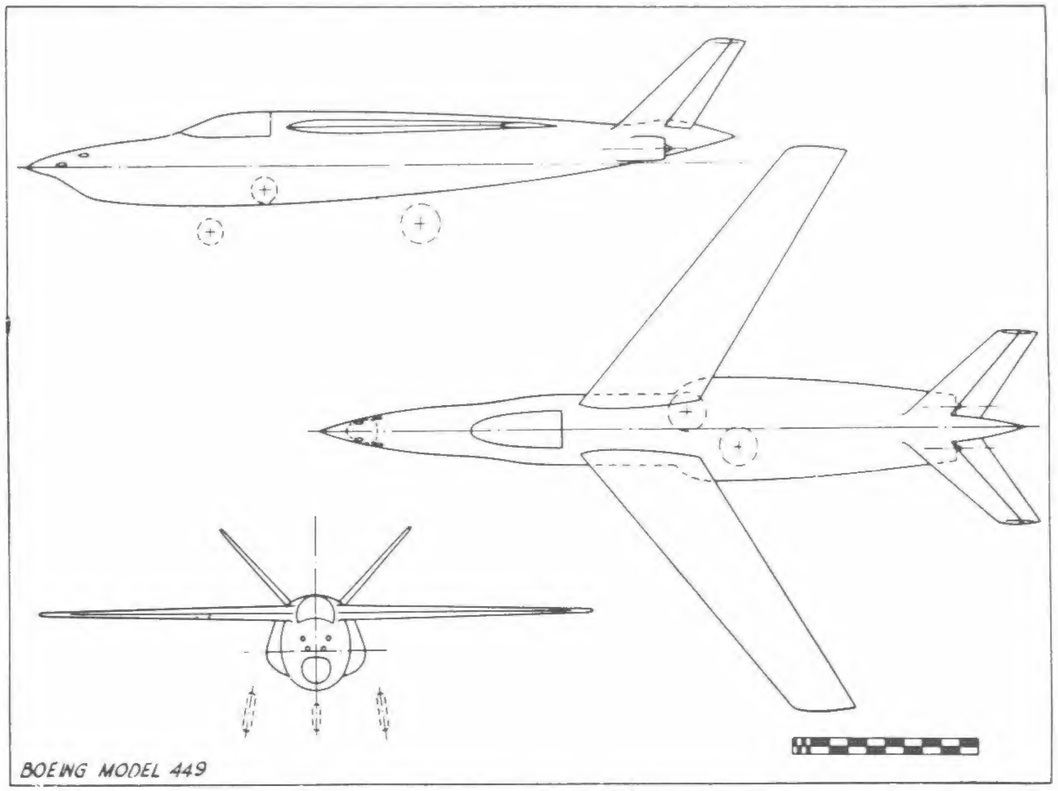
A twin-engine fighter designed in 1942 to the same Navy specifications as the Grumman F7F Tigercat. Two Wright R-1820 Cyclone engines of 1,350 hp. Span 46 ft, length 42 ft, gross weight 18,971 lb.



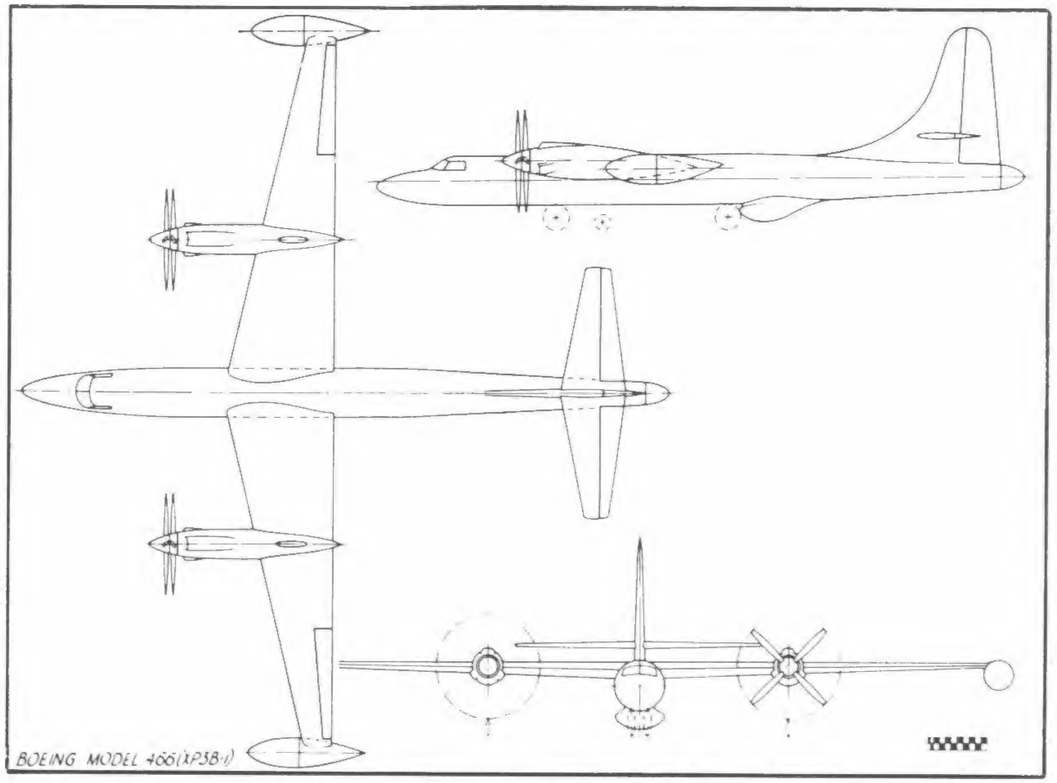
Small two-seat helicopter designed in 1943 as either an open cockpit or enclosed cabin model. Engine Lycoming 0-435D, 212 hp. Rotor diameter 36 ft, length 34 ft, gross weight 2,250 lb.



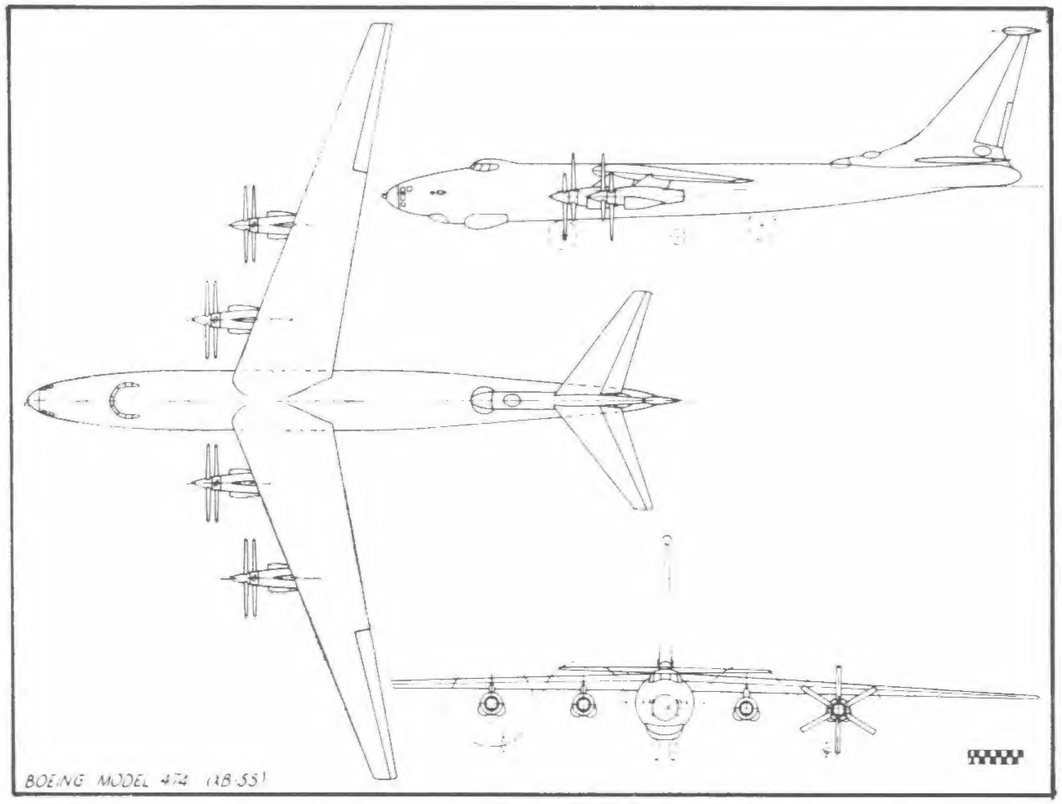
A Wichita Division design for a 17-passenger feeder transport for the anticipated post War-II market. Construction of this final design of many studied under the same basic model number was actually under way when the project was cancelled. Two 800 hp Wright 7BA-1 Cyclone engines. Span 86 ft 8 in, length 63 ft 2 in, gross weight 18,750 lb.



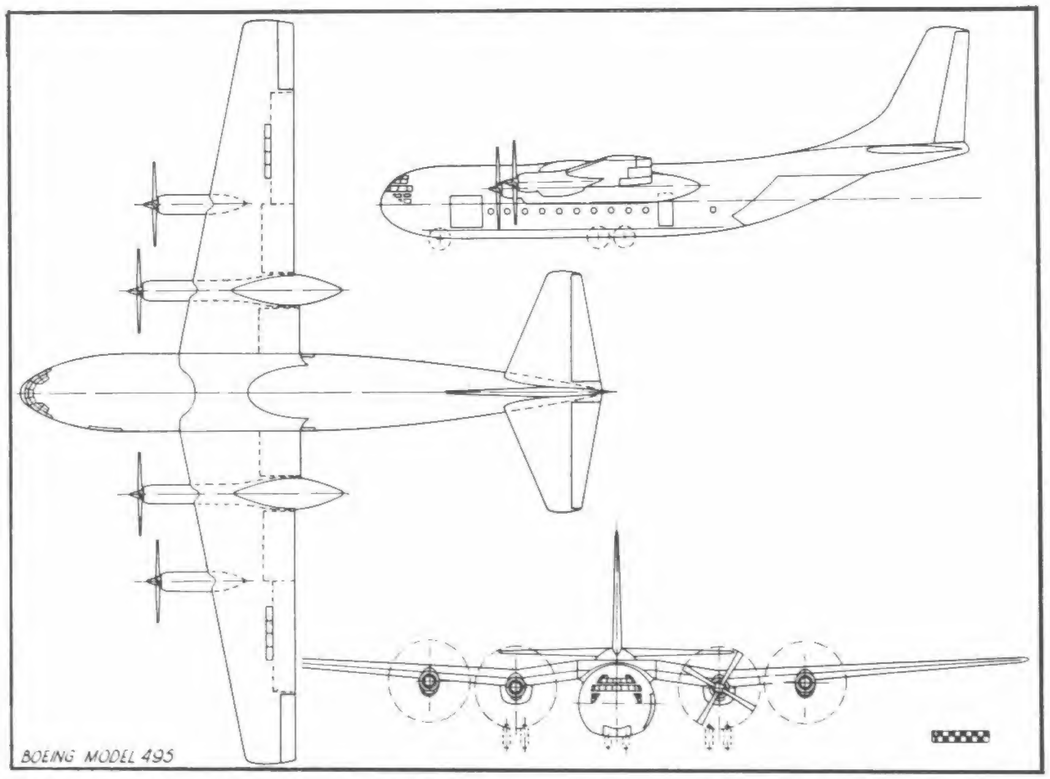
Single-seat jet-powered interceptor fighter designed in 1946. Twin Westinghouse engines. Span 30 ft, length 38 ft 5 in, gross weight 8,660 lb.



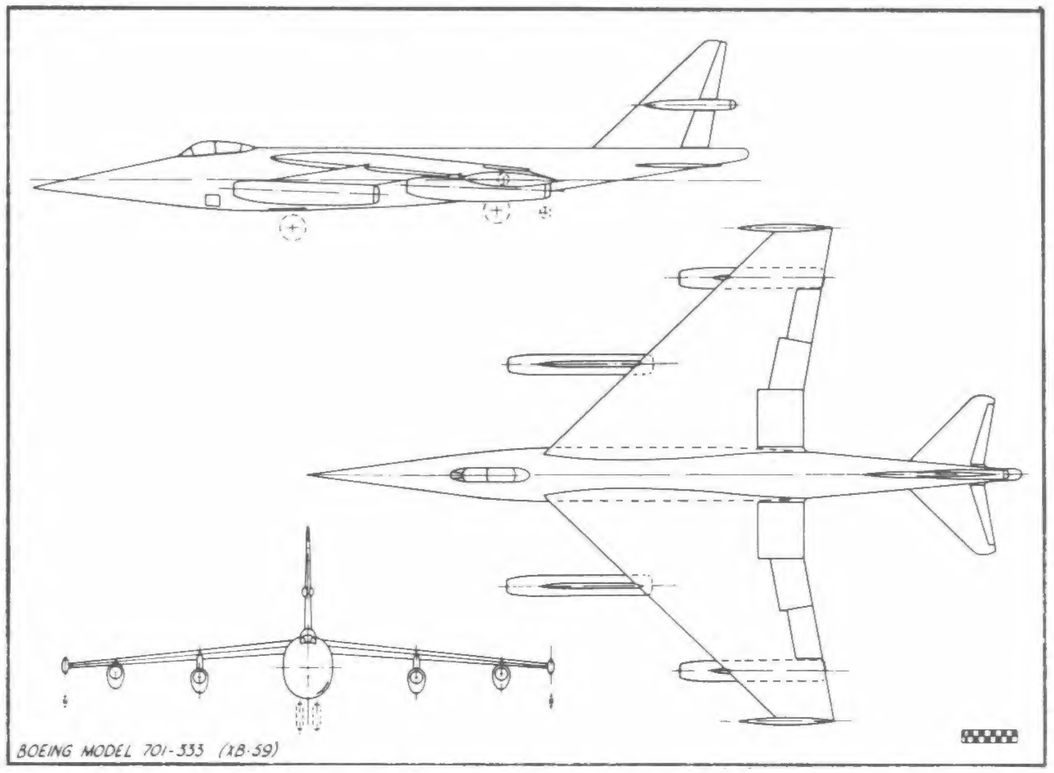
Twin turboprop patrol aircraft of 1947 designated XP3B-1 by the Navy before the project was abandoned. Two 5,200 hp Allison XT-40 engines. Span 110 ft, length 90 ft 6 in, gross weight 92,000 lb.



XB-55 of 1948 was a turboprop adaptation of the jet-powered XB-47 (Boeing Model 450). Four Allison T-40A-2 engines. Span 135 ft, length 118 ft 11 in, gross weight 153,000 lb.



A 1950 design for a turbine-powered tail-loading military transport competitive with the Lockheed C-130. Four 5,700 hp Pratt & Whitney T-34P-6 engines. Span 140 ft, length 112 ft 10 in, gross weight 143,500 lb.



One of many configurations studied under a USAF contract for the three-seat XB-59 bomber. Four General Electric J-73 engines of 9,300 lb thrust. Span 81 ft 4 in, length 123 ft 4 in, gross weight 148,300 lb.

Appendix II

TYPE CERTIFICATES ISSUED TO COMMERCIAL BOEING AEROPLANES 1927–89

APPROVED TYPE CERTIFICATE (ATC)

Issued to aircraft that meet full licensing requirements for unlimited commercial operation. Approval is usually granted as a result of the manufacturer's test programme before the first article is delivered to the customer.

Into the early years of the jet era, it was customary to issue a new ATC when minor structural changes and engine changes were made to the basic model, as 707-100 and 707-300. Now a great variety of engine and structural combinations are accommodated under a single ATC number.

ATC No.	*Boeing model*	*Date issued*
A-2	40A	July 26, 1927
A-23	B-1D	April 30, 1928
A-27	40B	Feb 25, 1928
A-54	40C	July 14, 1928
A-64	B-1E	Aug 24, 1928
A-106	95	Jan 30, 1929
A-133	100	April 1, 1929
A-157	204	June 6, 1929
A-183	40B-4	July 26, 1929
A-206	80A	Aug 20, 1929
A-211	203A	Aug 24, 1929
A-330	200	June 24, 1930
A-366	221	Sept 16, 1930
A-500	247	March 16, 1933
A-524	247A	Jan 3, 1934
A-558	247D	Oct 11, 1934 (Renewed Sept 6, 1940)
A-704	314, 314A	Jan 25, 1939
A-719	S-307	March 13, 1940
A-726	SA-307B	May 4, 1940
A-743	Stearman 75	June 3, 1941 (Renewed April 21, 1945) June 24, 1949
A-812	377	Sept 3, 1948
4A-23	707-100	Sept 18,1958
	707-120B	March 1, 1961
	707-138	June 24, 1959
	707-200	Oct 5, 1959
4A-26	707-300	July 19, 1959

Appendix V

SERIAL NUMBERS OF US ARMY AND AIR FORCE AIRCRAFT DESIGNED OR BUILT BY BOEING From 1917

This appendix lists the US Army and Air Force serial numbers assigned to military aircraft built by Boeing or associate contractors and to former civil Boeings requisitioned by the military during World War II. Two numbering systems are presented; the straight numerical sequence system of 1908–21 and the Fiscal Year system of 1922 to date, under which the serial numbers are assigned in sequence of aeroplane procurement within a particular fiscal year (22-1000/1049 for 1,000th or 1,049th procured in fiscal 1922). Because of changes over the years, the prefix letters SC for Signal Corps, AS for Air Service, AC for Air Corps, etc, are not used.

As in the other appendices, the serial numbers are grouped by blocks whenever possible. It has been necessary to list most of the de Havilland 4 conversions individually as these aeroplanes were random selections from war-surplus stocks and cannot be grouped by serial numbers.

BOEING-DESIGNED AIRCRAFT PURCHASED BY US ARMY AND AIR FORCE

Military serial no	*Military designation*	*Boeing model*	*C/n*	*Remarks*
536,537	EA	4	4,5	Primary trainer
22884	XCO-7	42	520	Redesigned DH-4M-1
22886	DH-4M-1	16	529	Rebuilt DH-4
22912	,,	,,	539	,,
22974	,,	,,	559	,,
22979	,,	,,	569	,,
22981	,,	,,	579	,,
23000	,,	,,	588	,, ; to DH-4M-1T
23006	,,	,,	597	,,
23007	,,	,,	606	,,
23109	XCO-7A	42	519	Redesigned DH-4M-1
23340	DH-4M-1	16	530	Rebuilt DH-4
23447	,,	,,	540	,,
23570	,,	,,	490	,,
23574	,,	,,	476	,,
23578	,,	,,	475	,,
23579	,,	,,	472	,,
24171	,,	,,	468	,,
24180	,,	,,	462	,, ; to DH-4M-1T
24185	DH-4M-1	16	466	Rebuilt DH-4; to -1T
24189	,,	,,	477	,,
24297	,,	,,	470	,,
24298	,,	,,	479	,,
24300	,,	,,	485	,,

Military serial no	*Military designation*	*Boeing model*	*C/n*	*Remarks*
24301	DH-4M-1	16	463	Rebuilt DH-4; to -1T
24302	,,	,,	484	,,
24303	,,	,,	488	,,
24304	,,	,,	496	,, ; to DH-4M-1T
24305	,,	,,	469	,,
24307	,,	,,	473	,,
24314	,,	,,	494	,,
24318	,,	,,	495	,, ; to DH-4M-1T
24319	,,	,,	492	,,
24324	,,	,,	486	,,
24325	,,	,,	482	,,
24328	,,	,,	489	,,
24330	,,	,,	481	,,
29125	,,	,,	550	,,
29133	,,	,,	499	,,
29136	,,	,,	510	,,
29138	,,	,,	560	,,
29154	,,	,,	570	,,
29183	,,	,,	509	,,
30131	,,	,,	491	,,
30135	,,	,,	502	,,
30210	,,	,,	493	,,
30248	,,	,,	471	,,
30251	,,	,,	480	,,
30280	,,	,,	504	,,
30284	,,	,,	467	,,
30422	,,	,,	464	,,
30433	,,	,,	503	,,
30443	,,	,,	465	,,
30446	,,	,,	487	,,
30456	,,	,,	474	,,
30517	,,	,,	501	,,
30520	,,	,,	483	,,
30708	,,	,,	506	. ; to DH-4 M-1T
30954	,,	,,	497	,,
30980	,,	,,	511	,,
31082	,,	,,	580	,,
31184	,,	,,	589	,,
31200	,,	,,	598	,,
31202	,,	,,	607	,,
31205	,,	,,	541	,,
31216	XCO-7B	42	521	Redesigned DH-4M-1
31219	DH-4M-1	16	531	Rebuilt DH-4
31220	,,	,,	551	,,
31242	,,	,,	561	,,
31246	,,	,,	571	,,
31260	,,	,,	581	,,
31262	,,	,,	590	,,
31265	,,	,,	599	,,
31271	,,	,,	608	,,
31274	,,	,,	522	,,
31287	,,	,,	532	,,
31298	,,	,,	542	,,
31301	,,	,,	552	,,
31306	,,	,,	562	,, ; to DH-4M-1T
31307	DH-4M-1	16	572	Rebuilt DH-4
31318	,,	,,	582	,,
31345	,,	,,	591	,,
31368	,,	,,	600	,,

Military serial no	*Military designation*	*Boeing model*	*C/n*	*Remarks*
31382	DH-4M-1	16	609	Rebuilt DH-4
31386	,,	,,	523	,,
31391	,,	,,	533	,,
31412	,,	,,	543	,,
31425	,,	,,	553	,,
31450	,,	,,	563	,,
31483	,,	,,	573	,,
31497	,,	,,	583	,,
31498	,,	,,	592	,,
31561	,,	,,	601	,,
31578	,,	,,	610	,,
31715	,,	,,	524	,,
31835	,,	,,	534	,,
31909	,,	,,	544	,,
31919	,,	,,	478	,,
31956	,,	,,	554	,, ; to DH-4M-1T
32087	,,	,,	564	,,
32093	,,	,,	574	,,
32104	,,	,,	584	,,
32172	,,	,,	593	,,
32188	,,	,,	602	,, ; to DH-4M-1T
32205	,,	,,	507	,,
32247	,,	,,	611	,,
32319	,,	,,	525	,,
32377	,,	,,	505	,,
32461	,,	,,	535	,, ; to DH-4M-1T
32476	,,	,,	545	,,
32512	,,	,,	555	,, ; to DH-4M-1T
32530	,,	,,	565	,,
32538	,,	,,	575	,, ; to DH-4M-1T
32578	,,	,,	585	,,
32703	,,	,,	500	,, ; to DH-4M-1T
32733	,,	,,	594	,, ; to DH-4M-1T
32734	,,	,,	603	,,
32739	,,	,,	612	,,
32752	,,	,,	526	,,
32772	,,	,,	536	,,
32807	,,	,,	508	,,
32814	,,	,,	546	,,
32815	,,	,,	556	,, ; to DH-4M-1T
32833	,,	,,	566	,,
32847	,,	,,	576	,,
32855	,,	,,	586	,,
32857	,,	,,	595	,, ; to DH-4M-1T
32862	,,	,,	498	,, ; to DH-4M-1T
32879	,,	,,	604	,, ; to DH-4M-1T
32888	,,	,,	613	,,
32890	,,	,,	527	,,
32894	,,	,,	537	,,
32901	,,	,,	547	,, ; to DH-4M-1T
32903	,,	,,	557	,, ; to DH-4M-1T
32920	,,	,,	567	,,
32932	,,	,,	577	,,
32951	,,	,,	549	,,
32956	,,	,,	587	,,
32957	,,	,,	596	,,
32975	DH-4M-1	16	605	Rebuilt DH-4
32984	,,	,,	614	,,
32994	,,	,,	528	,,
32996	,,	,,	538	,,

Military serial no	*Military designation*	*Boeing model*	*C/n*	*Remarks*
32998	DH-4M-1	16	548	Rebuilt DH-4
33006	,,	,,	558	,, ; to DH-4M-1T
33027	,,	,,	568	,,
33049	,,	,,	578	,,
63461/63507	DH-4B	,,	88/134	,,
63696	,,	,,	135	,,
63761/63823	,,	,,	136/198	,,
64146/64155	GA-1	10	200/209	Army design triplane
64235/64236	GA-2	10	410/411	Army design biplane
68237/68436	MB-3A	–	210/409	Thomas-Morse design
68590/68592	XDH-4M-1	16	515/517	Prototype DH-4M-1s
22-1000/1049	DH-4B	,,	412/461	Rebuilt DH-4
23-109	XCO-7A	42	519	23109 marked in error
23-1216/1218	XPW-9	15	512/514	
24-451/454	DH-4M-1	16	615/618	Rebuilt DH-4
25-295/306	PW-9	15	659/670	
25-307/323	PW-9	,,	720/736	
25-324	XP-4	58	737	Conv. from PW-9
26-351/373	PW-9A	15A	776/798	
26-374	AT-3	68	799	Conv. from PW-9A
26-375	PW-9B	15B	800	From PW-9A; to PW-9A
26-443/457	PW-9C	15C	837/851	
27-178/201	PW-9C	15C	852/875	
27-202	PW-9D	15D	876	Conv. from PW-9C
28-26/40	PW-9D	15D	1011/1025	
28-41	XP-7	93	1026	PW-9D to XP-7 to PW-9D
28-359	XP-8	66	806	
28-386	XP-9	96	1045	
29-329/341	P-12B	102B	1170/1182	29-329 to XP-12G to P-12B
29-353/361	P-12	102	1100/1108	
29-362	XP-12A	101	1109	From last P-12
29-433/450	P-12B	102B	1183/1200	
30-29/87	P-12B	102B	1201/1259	
31-147/229	P-12C	222	1262/1344	
31-230/242	P-12C	222	1346/1358	
31-243, 244	P-12D	227	1261, 1345	
31-245/277	P-12D	227	1359/1391	31-373 to XP-12H to P-12D
31-553/579	P-12E	234	1460/1486	see text for conversions
31-580/586	P-12E	234	1489/1495	
32-1/38	P-12E	234	1496/1533	
32-39/76	P-12E	234	1535/1572	
32-77	P-12F	251	1534	
32-78/99	P-12F	251	1573/1594	
32-100, 101	P-12F	251	1676, 1677	
32-301	YB-9	215	1459	
32-302	Y1B-9	214	1458	
32-303/307	Y1B-9A	246	1671/1675	
32-412/414	XP-26	248	1678/1680	To Y1P-26, P-26
33-28/138	P-26A	266	1804/1914	
33-179, 180	P-26B	266A	1916, 1919	
33-181	P-26C	266	1915	
33-182, 183	P-26C	266	1917, 1918	
33-184/191	P-26C	266	1920/1927	
33-192	P-26C	266	1928	
33-193/203	P-26C	266	1929/1939	
34-23	YP-29	264	1941	

-3T9ER	Lauder Air	OE-LAU	23765
		As N767PW for PW engine tests	
-3Z9ER	Lauder Air	OE-LAV	24628

Appendix IX

BOEING JET AIRLINER DELIVERIES - 1958–1988

The following table lists Boeing Jet Airliners by year of delivery from first delivery to a customer (PAA) on September 30, 1958, to December 31, 1988.

Year	*707*	*727*	*737*	*747*	*757*	*767*	*Total*
1958	8						8
1959	77						77
1960	91						91
1961	80						80
1962	68						68
1963	34	6					40
1964	38	95					133
1965	61	111					172
1966	83	135					218
1967	118	155	4				277
1968	111	160	105				376
1969	59	115	114	4			292
1970	19	54	37	92			202
1971	10	33	29	69			141
1972	4	41	22	30			97
1973	11	92	23	30			156
1974	21	91	55	22			189
1975	7	91	51	21			170
1976	9	61	41	27			138
1977	8	67	25	20			120
1978	13	118	40	32			203
1979	6	136	77	67			286
1980	3	131	92	73			299
1981	2	94	108	53			257
1982	8	26	95	25	2	20	176
1983	8	11	82	23	25	55	204
1984	8	8	67	16	18	29	146
1985	3	0	115	24	36	25	203
1986	4	0	141	35	35	27	242
1987	9	0	161	23	40	37	270
1988	0	0	165	24	48	53	290
Total	981	1,831	1,649	710	204	246	5,621

Total orders at September 30, 1988, stood at 6,587.

Index I

BOEING AIRCRAFT BY MODEL NUMBER

This index lists all Boeing designed or built aircraft in Boeing Model Number sequence. To simplify identification of models, military or civil designations are shown in brackets after the Model Number.

Index II

BOEING AIRCRAFT BY NAME

This index lists Boeing designed or built aircraft by name or other Boeing designation. Some names are those given by Boeing or the armed services to a basic model, such as the B-17 Flying Fortress; some are names given to sub-models, such as the US Navy 707/E-6A 'Hermes'; some are the names of programmes involving particular aircraft; and some are names given by crews to individual aeroplanes.

Index III

BOEING AIRCRAFT BY ARMY OR AIR FORCE DESIGNATION

Index IV

BOEING AIRCRAFT BY NAVY DESIGNATION

Index V

AIRCRAFT OF OTHER MANUFACTURERS

This index lists aircaft and products of other manufacturers which were built under licence by Boeing, influenced Boeing design, or competed with or worked with Boeing aircraft.